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A PRELIMINARY REVISION OF THE GENUS *MYLOTHRIS* HÜBN. (1819) (LEP. RHOP. PIERIDAE)

By G. Talbot, F.R.E.S.

Manuscript received 15 April, 1942.

(Read 5 April, 1944.)

With One Plate.

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Introduction.

The genus *Mylothris* is a natural and distinct one, composed for the most part of closely allied forms. Some of these have long been a puzzle to systematists; most of them were treated as species by previous authors. No attempt to revise the genus has hitherto been made since it was dealt with by Aurivillius in 1910 (Seitz's *Macrolep.* **13**), although a number of new forms have been described in the interval. In 1932, *Lep. Cat.* **53**, the present writer listed 43 species. This total is now reduced to 23, including one new one.

Mylothris appears to have a distant relationship with the oriental genus *Delias*. Both genera are montane, and the larvae feed on various species of *Loranthus*. In *Mylothris* the early stages are known only of about two species. Those of *M. agathina* are well described and figured in Trimen, *South African Butterflies* **3** : 31, and **2**, pl. 2, fig. 3. The larva and pupa of *Delias*, especially the former, are somewhat distinct from those of *Mylothris*. The pupa of *Mylothris* approximates more to those of *Belenois* and *Anapheis*, being more closely allied to the former genus.

The venation of the fore-wing in the allied genera appears to be as follows :—

Delias.—Vein 7 + 8 present, 9 present, 10 absent, 11 free.

Pseudomylothris.—Vein 7 + 8 present, 9 and 10 absent, 11 free.

Mylothris.—Vein 7 + 8 absent (occasionally present), 9 to 12 present, 11 free.

Belenois.—All veins present, 11 free.

Anapheis.—All veins present, 11 anastomosed with 12.

♂ *genitalia*.—The valve is furnished with a flap-like process, the harpe. This arises from the dorsal basal part of the valve. It consists of a more or less sclerotised lobe with a membranous attachment to the fold of the valve; it is thus capable of being raised from its normal flat position to a vertical

one. Usually the lobe is more or less excavated on its ventral side, this side being in such case more or less bilobed. The shape varies a good deal, ranging from a narrow finger-like organ to a broad and rounded one.

The males of most species were dissected, the character of the harpe providing a useful taxonomic aid.

The genus may be divided into 4 species-groups comprising respectively one, two, four, and sixteen species.

The material examined was large, comprising that of the British Museum (N.H.) and of the Hope Dept., Oxford, both collections being arranged in course of study. The only species not examined is *flavicosta* Rebel. The arrangement adopted at the British Museum is that given in the Systematic List in section (B) of this paper.

I am indebted to Dr. A. S. Corbet for the drawings of figs. 4, 5, 11, 12, 14, 18, 19, 20, 21, 22, 23, 24. The other figures were drawn by Mr. N. Bennett from specimens in the Hill Museum, now incorporated in the British Museum (N.H.).

Twenty-four new forms (including one species) are herein described. The types, and others recorded, unless otherwise stated, are in the British Museum (N.H.).

For facilities accorded him in the preparation of this paper the author is indebted to the Trustees of the British Museum, and to Professor G. D. Hale Carpenter, of the Hope Dept., University Museum, Oxford.

Abbreviations used.

Fw.	Fore-wing.	*Dc.*	Discocellular.
Hw.	Hind-wing.	*Udc.*	Upper discocellular.
Ups.	Upperside.	*Mdc.*	Middle discocellular.
Uns.	Underside.	*Ldc.*	Lower discocellular.
Gr.-col.	Ground-colour.	*Nom.*	Nominotypical.
P.-d.	Post-discal.		
S.-m.	Submarginal.		

(B) Systematic List of the species and forms of *Mylothris*.

(The letters B.M.T. following a name indicate that the type is in the British Museum (N.H.).)

Full references will be found in Talbot, 1932, *Lep. Cat.* **53**, pt. 1; later references are cited below. Forms described as new in the present paper are indicated by an asterisk.

trimenia Group.

1. *splendens* Le Cerf, 1927 (♂♀, Madagascar) (= *audeoudi* Riley, 1930. B.M.T.).
   ♂ f. *bicolor* Riley, 1930. B.M.T.
   ♀ f. *unicolor* Riley, 1930. B.M.T.
   Madagascar.
2. *smithi* (Mabille), 1879 (♂♀, Madagascar). B.M.T.
3. *trimenia* (Butler), 1869 (♂, Port Natal). B.M.T.
   Natal; Pondoland; Kaffraria.
4. *croceus* Butler, 1896 (♂, Ruwenzori). B.M.T.
   Form *marginea* Joicey & Talbot, 1925 (♂, Kivu). B.M.T.
   Uganda (Ruwenzori, Toro); Eastern Congo (Ruanda, Kivu).

chloris Group.

5. *similis similis* Lathy, 1906 (♂♀, Nyasaland, Mlanji). B.M.T.
   Nyasaland (Mlanji Plateau); Tanganyika Territory (Zanzibar).
   similis dollmani Riley, 1921 (♂♀, N.W. Rhodesia). B.M.T.
   ♀ f. *flavida* Riley, 1921. B.M.T.
   North-west Rhodesia; Katanga.
   **similis noël* Talbot, nov. (♀, N.E. Uganda). Type in Hope Dept., Oxford.
6. **elodina* Talbot, nov. (♂♀, Cameroons). B.M.T.
   Cameroons; Angola; N.E. Congo.
7. *nagaziya* (Oberthür), 1888 (♂♀, Great Comoro). B.M.T.
   ♂ f. *humbloti* (Oberth.), 1888 (Great Comoro). B.M.T.
   *♀ f. *albunea* Talbot, nov. (Great Comoro). Type in Hope Dept., Oxford.
   Comoro Islands.
8. *phileris* (Boisduval), 1833 (♂♀, Madagascar). ♂, B.M.T.
   Form *thinaga* Suffert, 1904 (♂, in Mus. Berl.).
   Form *aurata* Oberthür, 1923. ♂, B.M.T.
   Form *flavescens* Oberthür, 1923. *Et. Lép. comp.* **21** (2) : 121. (♂♀, B.M.T.)
   Madagascar.
9. *chloris chloris* (Fabricius), 1775 (♂, Sierra Leone). B.M.T. (♀ = *thermopylae* Cram., 1779).
   Form *richlora* Suffert, 1904 (♂, Njam-Njam). B.M.T.
   Form *analis* Aurivillius, 1907 (♂♀, French Congo).
   ♀ f. *intermedia* Aurivillius, 1910 (Cameroons).
   Senegal to Cameroons, western Congo, South Sudan.
   chloris clarissa Butler, 1888 (♀, Wadelai). B.M.T.
   ♀ f. *wintoniana* Sharpe, 1891 (Kavirondo).
   ♀ f. *ochrasiens* Stoneham, 1937 (W. Kenya). *Bull. Stoneham Mus.* **33**.
   ♀ f. *rubrochracea* Stoneham, 1937 (W. Kenya). *Bull. Stoneham Mus.* **33**.
   *♀ f. *ochreata* Talbot, nov. (W. Kenya). B.M.T.
   *♀ f. *nox* Talbot, nov. (Congo). B.M.T.
   *Form *agathinoides* Talbot, nov. (♂♀, Uganda, Kenya). B.M.T.
   Uganda and western Kenya to the Nivasha Rift.
   chloris agathina (Cramer), 1779 (♂, " Java ").
   *♀ f. *leucoma* Talbot, nov. (Angola). B.M.T.
   Abyssinia and Somaliland to Kenya (east of Nivasha Rift), Tanganyika Territory and Natal; eastern and southern Congo to Angola and South-West Africa.
10. *rembina* (Plötz), 1880 (♀, W. Cameroons).
   ♂ f. *subfusa* Crowley, 1890 (Cameroons). B.M.T.
   *♂ f. *arctata* Talbot, nov. (Cameroons). B.M.T.
   ♀ f. *rembina* Plötz.
   ♀ f. *infuscata* Bartel, 1905 (Edea, S.W. Cameroons).
   ♀ f. *fusca* Bartel, 1905 (Gaboon).
   *♀ f. *semifusca* Talbot, nov. (Congo). B.M.T.
   Gambia to Angola, Congo, Fernando Po, Principe.
11. *citrina citrina* Aurivillius, 1898 (♂♀, Bagamoyo). N.E. Tanganyika Territory.
   **citrina holochroma* Talb., nov. (♂, E. Congo, Kivu). B.M.T.
12. *ochracea* Aurivillius, 1895 (♂, Cameroons).

13. *sulphurea primulina* Butler, 1897 (♂, Lagos). B.M.T.
    Form *dimidiata* Aurivillius, 1898 (♂, Sierra Leone).
    Sierra Leone; Gold Coast; Ivory Coast. (Chiefly S. Leone; f. *primulina* is rare).
    sulphurea basalis Aurivillius, 1907 (♂, " Congo ").
    Gaboon; Cameroons; Spanish Guinea; Eastern Congo. (Chiefly eastern and north-eastern Congo; rare elsewhere).
    *Form *pallescens* Talbot, nov. (♂, Ivory Coast).
    sulphurea sulphurea Aurivillius, 1895 (♂, Cameroons). (= *flavia* Grose-Smith, 1898, ♂, Cameroons. B.M.T.).
    Form *flaviana* Grose-Smith, 1898 (♂, Cameroons). B.M.T.
    Form *solilucis* Schultze, 1914 (♂, S. Cameroons). (= *interposita* Joicey & Talbot, 1921, ♂, Eastern Congo. B.M.T.).
    Form *aurantiaca* Rebel, 1914 (♂, Beni, N.E. Congo).
    Ivory Coast; Nigeria; Cameroons; Angola; Congo; Uganda. (Chiefly in Cameroons and Nigeria; rare elsewhere).
14. *poppea rueppellii* (Koch), 1865 (♂, Abyssinia). (♀ = *kaffana* Riley, 1921. B.M.T.).
    Form *erlangeri* Pagenstecher, 1902 (♂♀, S. Abyssinia).
    Abyssinia.
    poppea septentrionalis Carpenter, 1928 (♂♀, Imatong Mtns., S. Sudan). Types in Hope Dept.
    South Sudan.
    poppea tirikensis Neave, 1904 (♀, Kenya, Tiriki Hills). Type in Hope Dept.
    ♂ f. *kenia* Riley, 1921 (Mt. Kenia). B.M.T.
    ♂ f. *aspilota* Hulstaert, 1924 (Kenya).
    ♀ f. *kikuyuensis* Bartel, 1905 (Kenya, Kikuyu).
    Uganda (rare) to Kenya and northern Tanganyika Territory.
    poppea rhodesiana Riley, 1921 (♂♀, Rhodesia). B.M.T.
    ♂ f. *pallidior* Hulstaert, 1924 (Congo).
    *♀ f. *pluviata* Talb., nov. (Morogoro). B.M.T.
    Tanganyika Territory; Nyasaland; N. Rhodesia; S.E. Congo; S.E. Angola.
    poppea haemus (Trimen), 1879 (♂♀, Cape Colony).
    Southern Rhodesia to Cape Colony.
    poppea poppea (Cramer), 1777 (♀, Guinea).
    Guinea to Togoland.
    poppea hilara (Karsch), 1892 (♂, Cameroons).
    Form *alcuana* Grünberg, 1910 (♀, Spanish Guinea) (= *excavata* Strand, 1913, ♀, Spanish Guinea).
    ♂ f. *asphodelus* Butler, 1888 (Cameroons). B.M.T.
    ♂ f. *limbonotata* Strand, 1913 (Cameroons).
    f. *conflua* Strand, 1913 (Cameroons).
    ♀ f. *dubia* Aurivillius, 1907 (French Congo).
    *♀ f. *trimacula* Talbot, nov. (Cameroons). B.M.T.
    *♀ f. *furvus* Talbot, nov. (Fernando Po). B.M.T.
    Nigeria; Cameroons; Congo. Rare in western Kenya.
    poppea continua Aurivillius, 1910 (♀, Ruwenzori).
    ♀ f. *umbratica* Talbot, 1932 (N.E. Congo). B.M.T.
    Uganda; north-east Congo. The form *asphodelus* occurs in Uganda.
15. *flavicosta* Rebel, 1914 (♂, N.W. Lake Tanganyika).

16. *sjöstedti sjöstedti* Aurivillius, 1895 (♂, Cameroons).
Cameroons.
sjöstedti pernaria Hulstaert, 1924 (♂, Belgian Congo, Stanleyville).
Belgian Congo.
17. *nubila nubila* (Möschler), 1884 (♂, Cameroons).
Cameroons; Gaboon; Sao Thomé.
nubila canescens Joicey & Talbot, 1922 (♂, Kivu); *id.*, 1925 (♀, Kivu). B.M.T.
Eastern Congo (Kivu).
18. **yulei bansoana* Talbot, nov. (♂♀, W. Cameroons). B.M.T.
yulei amhara Ungemach, 1932 (♂♀, Abyssinia).
Abyssinia.
yulei latimargo Joicey & Talbot, 1921 (♂, Kavirondo). B.M.T.
*Form *rhodopoides* Talbot, nov. (♂, Uganda; ♀, Nairobi). B.M.T.
Uganda; western Kenya; eastern Congo (rare); Katanga (rare); N.E. Rhodesia (rare).
yulei ertli Suffert, 1904 (♂, Kome I., Victoria Nyanza) (= *yulei* Butl., ♀).
Northern Tanganyika Territory; eastern Kenya (Mt. Kenia to Kilimanjaro).
yulei yulei Butler, 1897 (♂, N.W. Lake Nyasa). B.M.T. (= *latimargo* J. & T., ♀).
Form *sulphurascens* Hulstaert, 1924 (♂, Lake Mweru).
Nyasaland; S.E. Congo (rare).
19. *rhodope rhodope* (Fabricius), 1775 (♀, Sierra Leone). B.M.T.
♂ f. *schumanni* Suffert, 1904 (Konaky). B.M.T.
♂ f. *hintzi* Strand, 1912 (Cameroons) (= *spicatana* Strand, 1913, Cameroons).
♂ f. *spicatella* Strand, 1913 (Cameroons).
♀ f. *eudoxia* (Boisd.), 1836 (Guinea Coast). B.M.T.
♀ f. *spica* (Möschler), 1884 (Gold Coast).
♀ f. *caspi* Suffert, 1904 (Cameroons) (= *flavicosta* Neustetter (*non* Rebel), 1913). B.M.T.
♀ f. *beethoveni* Suffert, 1904 (Cameroons). B.M.T.
♀ f. *pseudohilara* Strand, 1912 (Cameroons) (= *hilara* Auriv. (*non* Karsch), 1910).
♀ f. *spicana* Strand, 1913 (Cameroons).
Form *fernandina* Schultze, 1914 (♂♀, Fernando Po).
Gambia to Cameroons, Fernando Po, Angola and Congo generally.
**rhodope uniformis* Talbot, nov. (♂♀, Uganda). B.M.T.
Uganda; western Kenya (rare).
20. *mortoni* Blachier, 1912 (♂, Kaffa, Abyssinia).
Form *balkis* Ungemach, 1932 (♂♀, Abyssinia).
♀ f. *continua* Ungemach, 1932 (Abyssinia).
Central to western Abyssinia.

sagala Group.

21. *sagala knutsoni* Aurivillius, 1891 (♀, Cameroons River).
*Form *discus* Talbot, nov. (♂♀, W. Cameroons). B.M.T.
Western Cameroons.
sagala swaynei Butler, 1899 (♂, Harrar Highlands). B.M.T.
East and central Abyssinia.

**sagala nagichota* Talbot, nov. (♂♀, S. Sudan). Hope Dept.
South Sudan.
sagala jacksoni Sharpe, 1891 (♀, Kavirondo). B.M.T.
Form *neumanni* Sharpe, 1896 (♂♀, Kenya). B.M.T.
Form *striata* Aurivillius, 1910 (♂, Mt. Kenia).
*Form *insignis* Talbot, nov. (♂♀, Uganda). B.M.T.
S.W. Abyssinia; Semliki Valley; Ruanda; Kivu; Uganda; Kenya (to Mt. Kenia and south-central). More frequent in Kenya than elsewhere.
sagala narcissus Butler, 1888 (♂♀, Kilimanjaro). B.M.T.
♂ f. *aequimargo* Thurau, 1903 (Poroto to Rungwe).
♀ f. *decora* Thurau, 1903 (Langenberg).
♀ f. *dulcis* Thurau, 1903 (Langenberg).
Eastern Kenya to Kilimanjaro and western Tanganyika Territory to north Lake Nyasa.
sagala sagala Grose-Smith, 1886 (♂, Sagala, N.E. Tanganyika Territory). B.M.T.
*Form *seminigra* Talbot, nov. (♂♀, Morogoro). B.M.T.
Eastern Tanganyika Territory to south end Lake Nyasa.
sagala dentatus Butler, 1896 (♂, Nyika distr., Nyasaland). B.M.T.
Form *crawshayi* Butler, 1896 (♂♀, Nyika, Nyasaland). B.M.T.
Northern Nyasaland, Nyika district.
**sagala albissima* Talbot, nov. (♂♀, N.E. Rhodesia). B.M.T.
Northern Rhodesia.
22. *ruandana* Strand, 1909 (♂, Ruanda).
Ruanda and Kivu.

bernice Group.

23. *bernice bernice* (Hewitson), 1866 (♂♀, Gaboon). B.M.T.
♀ f. *pallescens* Gaede, 1916 (Cameroons).
French Congo; Cameroons; Gaboon.
bernice rubricosta (Mabille), 1890 ("♂," Mozambique).
Form *berenicides* Holland, 1896 (♀, Kenya).
♀ f. *sulphureotincta* Strand, 1909 (Ruanda).
*♀ f. *fuscescens* Talbot, nov. (E. Congo). B.M.T.
Abyssinia; South Sudan; N.E. Congo to Kivu; Uganda; Kenya (to Nivasha Rift and Nairobi); Tanganyika Territory.
**bernice attenuata* Talbot, nov. (♂, Lake Nyasa; ♀, N.E. Rhodesia). B.M.T.
S.E. Congo; Nyasaland; N. Rhodesia.

Pseudomylothris Neust. (1929).

leonora Krüger, 1928 (♀, Tanganyika Territory, Ukami). B.M.T.

(C) Keys to the Groups and Species of *Mylothris*.

Key to the species-groups of *Mylothris*.

1(4). Hw. ups. normally with seven marginal spots; in cases where hw. is without spots the fw. has a marginal black border reaching tornus.[1]

[1] In *croceus* f. *marginea* the hw. has only six spots.

2(3). Ups. fw. marginal spots all free or at least those on veins 2 to 4 . . . . . *trimenia* group.
3. Ups. fw. marginal border reaching tornus, rarely only to vein 4 *sagala* group.
4. Hw. ups. with six marginal spots, rarely absent.[2]
5(6). Ups. fw. cell brick-red at the base . . . . . *bernice* group.
6. Ups. fw. cell not brick-red at the base . . . . . *chloris* group.

trimenia Group.

Facies.—Hw. with seven spots, except in one form of one species. Fw. with marginal spots 2 to 4 always free; no red colouring.

Genitalia.—Valve always with a short apical projection. Harpe broad and relatively long, without lateral convexity or this slightly developed.

Key to species of *trimenia* group.

(The number following the species indicates its position in the Systematic List.)

1(4). Fw. with two distal costal spots (♂♀).
2(3). Fw. ochraceous (♂♀) . . . . . *splendens* Le Cerf. 1.
3. Ups. fw. posteriorly pale orange-yellow from base to tornus (♂); entirely white with yellow tinge, hw. white (♀) . . . *smithi* (Mab.). 2.
4. Fw. without distal costal spots.
5(6). Ups. fw. white, hw. yellow (♂); hw. ochraceous (♀) *trimenia* (Butl.). 3.
6. Ups. ochraceous-orange (♂); pale ochraceous (♀) . *croceus* Butl. 4.

chloris Group.

Facies.—Hw., except in *mortoni*, with 6 spots. *M. mortoni* has 7 spots on uns. in both sexes and on ups. in the ♀. Fw. coloration and pattern variable.

Genitalia.—Valve always with a short apical projection. Harpe of variable form, and usually with a prominent lateral convexity or protuberance, the lobe being deeply excavated in many forms.

Key to species of the *chloris* Group.—Males.

(The number following the species indicates its position in the Systematic List.)

1(16). Ups. fw. white or basal area with a reddish tinge only; no black dusting.
2(12). Uns. fw. a basal yellow area.
3 (4). Ups. fw. costal edge, from marginal border to base, not darkened *elodina* Talb. 6.
4. Ups. fw. costal edge darkened, at least in basal part.
5 (6). Ups. fw. marginal spot on vein 5 free from apical black *phileris* (Boisd.) 8.
6. Ups. fw. spot on vein 5 not free from apical black.
7 (8). Uns. hw. a black stripe in area 1*c* . . . . . *mortoni* Blach. 20.
8 (9). Ups. fw. marginal black to veins 3 or 2 . . . *rhodope* (Fabr.). 19.
9. Ups. fw. marginal black usually not reaching below vein 4.
10(11). Uns. fw. basal yellow extending into base of area 2. Ups. fw. marginal spots, at least on veins 2 to 4, free . . *similis* Lathy. 5.
11. Uns. fw. basal yellow not extending into base of area 2. Species below average size . . . . . *yulei* Butl. 18.
12(13). Uns. fw. basal yellow vestigial or absent . . . . *rembina* (Plötz). 10.

[2] The ♀ of *mortoni* has seven spots.

13(14). Uns. fw. basal area orange-red.
14(15). Ups. hw. costal area yellow . . . . . *nagaziya* (Oberth.). 7.
15. Ups. hw. costal area white . . . . . *chloris* (Fabr.). 9.
16(17). Ups. fw. white, without black dusting, but with a well-defined basal area of another colour, the lower edge of which does not reach beyond vein 3 and usually not beyond vein 2
poppea (Cram.)–*rueppellii* (Koch). 14.
17(20). Ups. fw. white; basal area or more of cell and costa dusted black.
18(19). Uns. fw. a basal yellow area . . . . . *sjöstedti* Auriv. 16.
19. Uns. fw. basal yellow absent or vestigial . . . *nubila* (Möschl.). 17.
20(21). Ups. fw. ochraceous to lemon-yellow at least in part, and if in basal area only this colour extends at least to end of cell.
21(22). Ups. fw. entirely ochraceous, not canary-yellow *ochracea* Auriv. 12.
22(23). Ups. fw. costal area and vein-streaks ochraceous yellow
flavicosta Rebel. 15.
23. Ups. fw. sulphur-yellow to citron or canary-yellow.
24(25). Ups. fw. citron-yellow; spot on vein 3 small and free, not larger than spot on vein 2 of hw. . . . . *citrina* Auriv. 11.
25. Ups. fw. spot on vein 3 usually not free, larger than spot on vein 2 of hw.
sulphurea Auriv. 13.

Key to species of the *chloris* Group.—Females.

1 (2). Ups. fw. white without basal yellow; costal edge not darkened
elodina Talb. 6.
2. Ups. fw. with costal edge darkened at least in basal part.
3(35). Ups. fw. without a distinct basal red or yellow area, or without basal black dusting.
4(11). Ups. fw. with five or six marginal bars or streaks.
5 (8). Ups. fw. ochraceous.
6 (7). Ups. hw. a marginal black border angled at vein 5 *ochracea* Auriv. 12.
7. Ups. hw. with marginal spots . . . . . *r. rhodope* (Fabr.). 19.
8. Ups. white.
9(10). Uns. fw. with prominent basal orange or yellow
rhodope f. *pseudohilara* Strand. 19.
10. Uns. fw. basal yellow vestigial or absent
rhodope f. *fernandina* (Schultze). 19.
11. Ups. fw. a marginal border or spots.
12(17). Ups. fw. more or less dusky.
13(16). Ups. hw. dusky.
14(15). Uns. fw. with basal orange-red . . . . . *chloris* (Fabr.) form. 9.
15. Uns. fw. basal colour vestigial or absent . . . *rembina* (Plötz). 10.
16. Ups. hw. dull yellow . . . . . *nubila* (Möschl.). 7.
17(18). Ups. fw. yellow, hw. white . . . . . *citrina* Auriv. 11.
18(21). Ups. fw. white, hw. ochraceous.
19(20). Uns. fw. proximal half ochraceous . . . *similis dollmani* Riley. 5.
20. Uns. fw. a basal orange-red area . . . . . *chloris* forms. 9.
21. Ups. both wings white, yellow, or ochraceous.
22(23). Ups. fw. a marginal black border reaching below vein 2
nagaziya (Oberth.). 7.
23. Ups. fw. marginal black border not reaching below vein 2.
24(31). Uns. fw. white with basal yellow.
25(26). Uns. fw. basal yellow extending to vein 3 . . . *s. similis* Lathy. 5.
26. Uns. fw. basal yellow not extended beyond vein 2.
27(28). Ups. white. Fw. marginal border reaching veins 3 or 2
rhodope uniformis Talb. 19.

28. Ups. fw. marginal spots on veins 3 and 4 usually free.
29(30). Species of average size or more. Ups. fw. marginal spot on vein 5 free *phileris* (Boisd.). 8.
30. Species below average size. Ups. white or with basal yellow. Uns. hw. usually tinged yellow . . . . . *yulei* Butl. 18.
31(32). Uns. fw. basal yellow vestigial or absent . *sulphurea basalis* Auriv. 13.
32. Uns. fw. a basal red or orange-red area.
33(34). Uns. hw. yellow or ochraceous; no inner black stripe *chloris* (Fabr.) forms. 9.
34. Uns. hw. white; a black stripe in area 1*c* . . . *mortoni* Blach. 20.
35(36). Ups. fw. white with basal black dusting over cell and costal area *sjöstedti* Auriv. 16.
36. Ups. fw. a basal orange-red or yellow area, sometimes dusky, less distinct in yellow and ochraceous specimens.
37(38). Ups. fw. cell entirely blackish-brown . . *p. poppea* f. *furvus* Talb. 14.
38. Ups. fw. cell mostly orange-yellow, sometimes dusted black.
39(40). Uns. fw. basal yellow area large, extended into base of area 2. Hw. marginal spots small as in male . *poppea rueppellii* (Koch) forms. 14.
40. Uns. fw. basal yellow of small extent, not extended into area 2.
41(42). Ups. hw. marginal spots rather small, as in male *poppea hilara* (Karsch). 14.
42. Ups. hw. marginal spots large and prominently round *poppea continua* Auriv. 14.

sagala Group.

Facies.—Hw. yellow or ochraceous, with 7 marginal spots either above or below. In the species *ruandana* no spots are present in the male but are vestigial in some females. Fw. white or with a yellow tinge; outer border usually reaches tornus; costal border usually strongly blackened, the black scaling extending more or less into the cell.

Genitalia.—Valve without any apical projection, as in *bernice* group. Harpe very broad, short and rounded, similar to that of *bernice* and unlike that of other groups.

Key to species of the *sagala* group.

1(2). Ups. fw. without a basal yellow area (♂); outer marginal border more or less dentate (♀) . . . . . *sagala* Gr.-Sm. 21.
2. Ups. fw. with a basal yellow area (♂); outer marginal border not toothed (♀) *ruandana* Strand. 22.

(D) Distribution.

The distribution of the 23 species comprising the genus, within 10 geographical areas, is shown in the appended table (Table 1).

The majority of species (78 per cent.) occur in the region embraced by the Rift Valleys, *i.e.* in the eastern Congo, Uganda, western Kenya, and western Tanganyika Territory.

In the eastern and southern regions, from Kenya to the Cape and Angola, 13 species (56 per cent.) are found. The same number is found in the area embraced by the Cameroons, Gaboon, and islands of the Guinea Gulf.

Only 7 species (30·4 per cent.) are found in the Rain Forest region from Senegal to Nigeria, western and central Congo.

Relative to size of area the Cameroons possesses the greater number of species, 13 (or 56 per cent.), equal to the number occurring in the whole eastern region.

TABLE 1.

Distribution of *Mylothris*.

		Senegal to Nigeria	Cameroons, F. Po, S. Thomé, Principe	Gaboon, Congo, Uganda, W. Kenya	Sudan, Abyssinia, Somaliland	Angola, S.E. Congo, Rhodesia	Nyasaland, W. Tang. Terr.	E. Tang. Terr., E. Kenya	S. Rhodesia to Cape	Madagascar	Comoro Is.
1	*splendens*	—	—	—	—	—	—	—	—	×	—
2	*smithi*	—	—	—	—	—	—	—	—	×	—
3	*trimenia*	—	—	—	—	—	—	—	×	—	—
4	*croceus*	—	—	×	—	—	—	—	—	—	—
5	*similis*	—	—	×	—	×	×	—	—	—	—
6	*elodina*	—	×	×	—	×	—	—	—	—	—
7	*nagaziya*	—	—	—	—	—	—	—	—	—	×
8	*phileris*	—	—	—	—	—	—	—	—	×	—
9	*chloris* forms	×	×	×	×	—	—	—	—	—	—
	agathina forms	—	—	×	×	×	×	×	×	—	—
10	*rembina*	×	×	×	—	×	—	—	—	—	—
11	*citrina*	—	—	×	—	—	—	—	—	—	—
12	*ochracea*	—	×	—	—	—	—	—	—	—	—
13	*sulphurea*	×	×	×	—	×	—	—	—	—	—
14	*rueppellii* forms	—	—	×	×	×	×	×	×	—	—
	poppea forms	×	×	×	—	—	—	—	—	—	—
15	*flavicosta*	—	—	—	—	—	×	—	—	—	—
16	*sjöstedti*	—	×	×	—	—	—	—	—	—	—
17	*nubila*	—	×	×	—	—	—	—	—	—	—
18	*yulei*	—	×	×	×	×	×	×	—	—	—
19	*rhodope*	×	×	×	—	×	—	—	—	—	—
20	*mortoni*	—	—	—	×	—	—	—	—	—	—
21	*sagala*	—	×	×	×	—	×	×	—	—	—
22	*ruandana*	—	—	×	—	—	—	—	—	—	—
23	*bernice*	—	×	×	×	×	×	—	—	—	—
		5	12	17	7	9	7	4	3	3	1

Two species, which may ultimately be found to be conspecific, occur in Madagascar, and one in the Comoro Islands.

It will be observed that a greater number of species is found in mountainous areas.

(E) DESCRIPTIONS OF NEW FORMS OF *MYLOTHRIS*.

Mylothris similis Lathy **noël** subsp. n.

This name is based upon a single remarkable female. The significance of the name will be seen from the date of capture.

The insect may, perhaps, be assigned to the *agathina–chloris* complex, but it seems more nearly to belong to the species *similis* and allied to the subspecies *dollmani*. (See the revisional notes for information on this species.)

♀. In general appearance very close to the form *flavida* Riley. Ups. colouring more orange-yellow than ochraceous. Fw. markings more sharply defined than in *agathina*

forms, and wing more pointed as in *dollmani*; spots on veins 2 and 3 free, spot on vein 4 touching the apical black extending below vein 5. Hw. spots slightly smaller than in *dollmani*. Uns. orange-ochraceous as in *flavida*; fw. with similar white apical suffusion; spots exactly as in *flavida*. Hw. spots as in *flavida*; areas 1*a* and *b* paler; veins white, narrowly white-edged, to a greater extent than in *dollmani*. Both wings with fringes prominently white between the veins as in *dollmani*.

Habitat.—Uganda: N. Bugishu, Elgon, Bulago, *c.* 7000 feet, 24.xii.1928 (*G. D. H. Carpenter*), 1 ♀. In the Hope Dept., Oxford.

Mylothris elodina sp. n.

Resembles *rhodope* (Fabr.) with which it is probably mixed in collections. The fore-wing appears shorter and narrower, with a shorter marginal border.

♂. Ups. fw. with marginal border of variable width as in *rhodope*, not reaching below vein 3, in two out of three specimens not reaching spot on vein 3; a small spot on vein 2. Uns. marginal spots somewhat smaller than in most *rhodope*.

Genitalia (pl. 1 fig. 5).—Harpe a very broad and short single lobe unlike any form of *rhodope* or other species of the genus.

There appears to be a difference between the fw. length of males of *elodina* and *rhodope*; sufficient females of the former are not available for valid comparison.

For *elodina*, mean length of fore-wing = 24·0 mm. (3 ♂). For *rhodope*, mean length of fore-wing = 28·0 mm. (5 ♂). Between these means $t = 6{\cdot}71$, $n_1 + n_2 = 6$, $P < 0{\cdot}01$, showing the difference between the wing-lengths to be highly significant. That is, the difference found between the means for *elodina* and *rhodope* could occur by chance less than once in one hundred times and can be regarded as real. (*Vide* Fisher, *Statistical Methods for Research Workers*.)

♀. Closely resembles the male. In the single specimen the fw. border does not reach the large spot on vein 3, it extends to vein 4, and at costa is a little wider than in ♂.

Habitat.—Cameroons (*L. Conradt* 1896), ♂ *type* (marginal border reaching vein 4); *id.*, 1 ♂ (marginal border reaching vein 3). Angola: Quanza River (*Major J. Mechow*), 1 ♂ (marginal border reaching vein 4). N.E. Congo, East Epulu River, N. Ituri Valley, between Penghe and Irumu, March, 1920 (*T. A. Barns*), ♀ *allotype*.

A typical *rhodope* ♀ is in the collection also from the Ituri River area.

Mylothris nagaziya (Oberth.) ♀ form **albunea** form. n.

♀. The whole of the pale areas of both wings are white on both sides.

Habitat.—Great Comoro (*G. F. Leigh*), 1.viii., 2.viii., 4.ix., 5.ix.1911 (*type*). All in the Hope Dept., Oxford.

This form is not represented in the long series in the British Museum; all have the hw. at least pinkish, with yellow suffusion.

Mylothris chloris (Fabr.) form **agathinoides** form. n.

This connects the form *richlora* Suff. with *agathina* (Cram.).

♂. Ups. fw. usually with a marginal dot on vein 2; marginal spots on veins 3 and 4 usually free. Hw. spots large, as in *richlora*, and all free. Uns. with marginal spots larger

than in *agathina*, especially those on hw. Fw. with the two apical spots often connected. Hw. spots all free, those on veins 2 and 3 tend to be larger and are sometimes touching; colour ochraceous, as in *agathina*, to yellowish-white.

♀. Resembles the male in colour and markings, except that the marginal spots on fw. and on ups. hw. are larger.

Habitat.—UGANDA and KENYA: Eastern Mbale Distr., south of Mt. Elgon, 5 ♂; eastern Busoga Distr., 1 ♂; Mabera Forest, 2 ♂; Mumias, Kisumu road, 2 ♂; Maramas Distr., east of Mumias, 1 ♂; Entebbe, 1 ♂; eastern Ruwenzori, 1 ♂; Naisi Hills, north of Mumias, 1 ♂; southern slope of Mt. Elgon, 1 ♂; Nyanza Prov., 1 ♂; S. Unyoro, 1 ♂; Kamogamba, 2 ♂; Semliki Valley, 3 ♂; Gulu Distr., Uganda, 1 ♀ (in Hope Dept.); S. Kavirondo, 2 ♂ (in Hope Dept.). Congo: Kivu to Lake Edward, 1 ♂.

♂ *holotype* (included above) from Kyagive, Mulange, Mabera Forest, April to August, 1919 (*R. A. Dummer*). ♀ *allotype* from Kenya, Hoeysbridge (*C. R. S. Pitman*).

The above specimens occurred within the range of the subspecies *clarissa* Butl.

The following specimens were within the range of the subspecies *chloris* (Fabr.):—

SOUTH SUDAN, Mongalla Prov., 2 ♂ (in British Museum), 4 ♂, 1 ♀ (in Hope Dept.); Imatong Mtns., 2 ♂ (in Hope Dept.).

Mylothris chloris (Fabr.) ♀ form **ochreata** form. n.

This represents the yellow form of *agathinoides*. It is similar in colour to the paler females of *agathina*. In some specimens the fw. is white.

Type and another from KENYA: N. Kavirondo, Nyangori, 4800 feet, 18–19.v.1911 (*S. A. Neave*); Naisi Hills and Mt. Elgon, two; "Kenya," one. UGANDA: Kamagamba, Entebbe, and Semliki, four; W. Uganda and Entebbe, two (in Hope Dept.). SOUTH SUDAN, Mongalla Prov., one. BRITISH SOMALILAND (*C. L. Collenette*), two.

Mylothris chloris (Fabr.) ♀ form **nox** form. n.

♀. Ups. fuscous, resembling the female of *rembina* Plötz. Fw. whitish only in the posterior p.-d. area; base dull reddish; marginal spots indistinct, but small as in *agathina* female, those on veins 2 to 5 free. Hw. with inner area to vein 1*b* dirty white; marginal spots indistinct but larger than in *agathina*. Uns. greyish-white. Fw. with small orange-red basal area as in form *agathinoides*, and with similar marginal spots which are all free; a slight yellowish apical suffusion. Hw. spots and basal orange as in *agathinoides*; proximal half dusted with fuscous, with slight yellow tinge over the inner area.

Habitat.—"Congo Free State" (ex Coll. Adams), 1 ♀.

This form occurs probably within the area of the subspecies *clarissa* Butl.

The name *nox* may be applied also to melanic specimens of nom. *chloris*. One such is in the Hope Dept. from Southern Nigeria, Onitsha, July, 1910 (*J. A. de Gaye*), and may be described as follows:

♀. Ups. fw. with basal and costal areas, including cell, dusted with black. Hw. black border reaching middle of cell, its edge diffuse; basal pale area dusted black. Uns. as in normal female except that on hw. the basal yellow area is smaller.

Mylothris chloris agathina (Cram.) ♀ form **leucoma** form. n.

♀. Ups. chalky-white or washed with cream or pale buff on either wing. Uns. fw. white or with slight yellow tinge; apical border more or less ochraceous. Hw. white or with pale ochraceous tinge.

Habitat.—Angola (ex C. Ward, via Coll. Oberthür) (*type*); North Angola, Bembe Mines (*J. J. Monteiro*), one; North Angola, N'Dalla Tando, 2700 feet, 9.xii.1908 (*Dr. W. J. Ansorge*), one (slightly cream-colour). Tanganyika Territory, one; Congo, four; S. Africa: Bashee River, Caffraria (ex Coll. Trimen), one.

Typical examples are chalky-white on both sides with exception of apical yellow tinge on fw., and uns. of hw. with yellow tinge along outer border.

Between these white specimens and the common strongly ochraceous form occur all shades of ochraceous. Where both sides of fw. and ups. hw. are distinctly white the specimen is referred to *leucoma*.

Mylothris rembina (Plötz) ♂ form **arctata** form. n.

♂. Ups. fw. with marginal border not reaching vein 4; marginal spots distinct on veins 3 and 4. Hw. with a marginal row of six triangular spots. Uns. fw. with a marginal dot on vein 2 and spots on veins 3, 4 and 5, the latter one sometimes touching apical border. Hw. marginal spots as on ups., but rounded, larger, and sometimes touching one another.

Habitat.—Cameroons: Port Victoria (*Capt. Fitzroy*) (*type*); "Cameroons," 3 ♂; Old Calabar, 1 ♂; Principe I., 2.xii.1932 (*W. H. T. Tams*), 1 ♂; "Congo," 1 ♂.

Mylothris rembina (Plötz) ♀ form **semifusca** form. n.

♀. Ups. resembles *fusca* Bart. in colouring. Hw. with marginal spots as in f. *arctata*. Uns. fw. with seven marginal spots. Hw. with marginal spots as in *arctata*.

Habitat.—Congo: Landana (*type* and another, ex Coll. Oberthür); "Congo," 2 ♀; Gaboon, 1 ♀; Principe I., 2.xii.1932 (*W. H. T. Tams*), 1 ♀; loc. ?, 1 ♀.

Mylothris citrina holochroma subsp. n.

♂. Ups. sulphur-yellow. Fw. apical border somewhat wider than in *citrina*, about 4 mm. on vein 6; marginal spot on vein 4 touching apical border; spot on vein 3 much smaller; vein 2 with a dot as in *c. citrina*. Hw., in areas 1*a* and 1*b* white, with also a whitish tinge along outer margin; spots smaller than in *citrina*. Uns. colouring similar to that of ups. Fw. with pale orange suffusion over basal part of cell; inner area to vein 2 largely white. Hw. as on ups. Both wings with marginal spots as in *citrina*. Length of fw. 27 mm.; in 2 males of *c. citrina* it is 30–31 mm.

Habitat.—Belgian Congo: Kisenyi, 17.vi. to 1.viii.1926 (*F. G. Jackson*), 1 ♂.

Mylothris sulphurea basalis Auriv. form **pallescens** form. n.

♂. Ups. fw. citron-yellow as in *sulphurea* Auriv. but without any orange suffusion; marginal border as broad as in most *basalis* and similarly extending to below vein 2. Hw. pale citron-yellow above vein 3 where this colour merges into the outer marginal white; basal part of area 2 and below cell to fold in area 1*c* also pale citron; costal areas

7 and 8 and inner area white; marginal spots as in *basalis* and *sulphurea*. Uns. fw. with basal orange area as in *dimidiata* Auriv., but the wing tinged with yellow as in *sulphurea*. Hw. as on ups. but paler; area 8 orange.

Habitat.—Ivory Coast: Patokla, 1 ♂ (*type*). Uganda, eastern Province, Bugishu, 5000 feet, August, 1921 (*C. H. Lankester*), 2 males in Hope Dept.

Mylothris poppea rhodesiana Riley ♀ form **pluviata** form. n.

♀. Ups. fw. with apical black area broader than usual, reaching 7 mm. on vein 6, constricted in area 4 and touching the large marginal spot on vein 3; basal area pale ochraceous, sparsely dusted with black. Hw. white with small basal pale ochraceous area slightly dusted with black; marginal spots of moderate size. Uns. fw. white with ochraceous-orange area reaching beyond cell and becoming diffused towards outer margin below vein 4. Hw. chalky-white; marginal spots smaller than on ups.

Habitat.—Tanganyika Territory: Morogoro, June to August, 1922 (*C. G. Kirkham*), 1 ♀.

Mylothris poppea hilara (Karsch) ♀ form **trimacula** form. n.

♀. Ups. white. Fw. with very slight basal yellow tinge; marginal spots on veins 2 and 3 well separated; spot on vein 4 separated from the apical black or only connected with it by some diffuse black scaling in area 4.

Habitat.—Western Cameroons: Banso Mountains, north of Lumbo, 6000 feet, September, 1922 (*G. L. Bates*) (*type*); Northern Cameroons: Chang, August, 1922, 2 ♀.

Mylothris poppea hilara (Karsch) ♀ form **furvus** form. n.

♀. Ups. fw. with marginal dark border very wide, 8 mm. on vein 4, and reaching inner margin where it is about 5 mm. wide; above vein 5 the border is continuous with costal border to base; cell entirely darkened by brownish-fuscous, with basal dusky scaling below the cell; p.-d. pale area of wing slightly dusky. Hw. marginal spots with inner edges diffuse and with dusky scaling between the spots, forming a marginal nebulous band about 3 mm. wide; basal area dusky. Uns. as in *hilara* male, but fw. basal yellow extended over greater part of cell and into base of area 2.

Habitat.—Fernando Po, 3000 to 4000 feet, June, 1926 (*T. A. Barns*), 1 ♀. No male from this island is known to me.

Mylothris yulei bansoana subsp. n.

♂. Ups. not constantly different from *amhara* Ungem. Uns. marginal spots smaller than in *amhara*; basal yellow of smaller extent.

♀. Ups. creamy-white. Fw. marginal border as wide as in Uganda males, reaching vein 4 in one specimen and vein 3 in the other. Uns. fw. with yellowish apical area; marginal spots as in *amhara* or smaller. Hw. yellowish; marginal spots smaller than in *amhara*.

Genitalia. ♂ harpe with lobe strongly spatulate and not narrow elongate as in *amhara*.

Habitat.—Cameroons: near Banso, western Cameroons, 3000 feet, August, 1922 (*G. L. Bates*) (♂ *type* and another); Genderu, north Cameroons, 4000 feet, August, 1921, 1 ♂, 2 ♀ (♀ *allotype*). Also in the Hope Dept. from Banso Moun-

tains, 3000 feet, August, 1922 (*G. L. Bates*), 1 ♀; "Cameroons," 1 ♂ (ex Coll. Suffert). The latter specimen has fw. ups. with basal area very distinctly yellowish.

Mylothris yulei latimargo J. & T. form **rhodopoides** form. n.

♂. Ups. fw. with wider marginal border, usually about 4 mm. on vein 5, but may range from 2 to 5 mm., specimens with the narrower band being rare; the border usually reaches vein 3. Hw. marginal spots usually more strongly developed than in nom. *latimargo*. Uns. hw. and apical area of fw. strongly yellowish.

♀. Ups. fw. with border usually wider than in ♂, the wing tinged with yellow, especially in basal area. A specimen from Tanganyika Territory, placed here provisionally, is creamy-white above. Fw. marginal spots on veins 2 and 3 free, spot on 4 elongate and touching the border; edge of border with a tooth on veins 5 and 8.

Habitat.—UGANDA: Tero Forest, S.E. Buddu, 3800 feet, 26–30.ix.1911 (*S. A. Neave*) (*type* ♂ and 8 others); Mosezi, January and February, 1903 (*W. L. Doggett*), 1 ♂. KENYA: southern foot and slopes of Mt. Elgon, 5100–5800 feet, 8–13.vi.1911 (*S. A. Neave*), 1 ♂; Yala River, south edge of Kakumega Forest, 4800–5300 feet, 21–28.v.1911 (*S. A. Neave*), 1 ♂; Nairobi (*Dr. A. D. Milne*), 3 ♂, 1 ♀ (*allotype*). TANGANYIKA TERRITORY: Bukoba, 4.xii.1921 (*N. C. E. Miller*), 1 ♂; *id.*, 3.x.1921, 1 ♀.

Also in the Hope Dept.—UGANDA: 30 miles west of Victoria Nyanza, foot of Kakindu Hill, 1° 10′ S., 31° 30′ E. (*G. D. H. Carpenter*), March and April, 2 ♂, 1 ♀, July, 1 ♀; near Kisumu, 3770 feet, October (*A. Vincent*), 1 ♂. KENYA: Nyangori, 5000 feet, November, 1 ♂; Lumbwa, *c.* 7500 feet, January (*Rogers*), 1 ♂.

This form is easy to confuse with *rhodope*, but specimens of the latter from the same area possess a wider marginal band, and in the female the border reaches vein 2 or there is a prominent marginal spot on vein 2.

Mylothris rhodope uniformis subsp. n.

♂. Apparently not different from *r. rhodope*, with similar variation in width and contour of fw. border. A tendency to a smaller size of wing seems more marked.

♀. Resembles the male in facies and size. Ups. with a creamy or yellowish tinge. Fw. slightly yellow at base; marginal border usually with a distinct tooth on veins 2 to 4. Hw. spots usually but slightly larger than in the male. Uns. as in male, white or with a yellow tinge.

Habitat.—The whole of UGANDA, a series of males and 11 females in the British Museum; a series of males and 6 females in the Hope Dept., Oxford. KENYA: Yala River, S. edge of Kakunga Forest, 4800–5300 feet, 21–28.v.1911 (*S. A. Neave*), 2 ♂, 1 ♀; Ilala, Maramas Distr., 14 miles east of Mumias, 4500 feet, 18–21.vi.1911 (*S. A. Neave*), 2 ♂; Mengo, March, 1900, 1 ♀. Also in the Hope Dept. from the Tiriki Hills, Mt. Elgon, and Nairobi.

Holotype ♂, Mabiri Forest, Kyagive, Mulange, April to August, 1919 (*R. A. Dummer*). ♀ *allotype*, between Seziwa River and Kampala, 3500–3750 feet, 27–31.viii.1911 (*S. A. Neave*).

A female of this form is in the British Museum from the Oso River, N.W. Kivu, where *r. rhodope* occurs. Similarly a female of form *pseudohilara* is present from Uganda, S.E. Buddu, Tero Forest.

Mylothris sagala nagichota subsp. n.

♂. Ups. fw. with white area smaller than in *jacksoni*, its width along vein 3 being 6 mm., and along vein 4, 5 mm., as compared with 8 mm. and 7 mm. respectively in *jacksoni*; white area in cell also somewhat reduced. Hw. black apical border well developed, reaching vein 5 or below it. Uns. as in *jacksoni*.

♀. Ups. fw. with white area smaller than in male, proximally strongly incurved. Hw. and uns. as in male.

Habitat.—Southern Sudan : Didinga Mtns., Nagichot Station, 19.xii.1925 (*G. D. H. and Mrs. Carpenter*) (♂♀ *types*); *id.*, 18–31.xii.1925, 2 ♂, 2 ♀; *id.*, 1–6.i.1926, 3 ♂, 3 ♀; Nagichot Sta., 6700 feet, 9.xii.1933 (*Capt. J. G. Owen*), 1 ♂.

See Carpenter, 1928, *Trans. ent. Soc. Lond.* **76:** 25.

Mylothris sagala jacksoni Sharpe form **insignis** form. n.

♂♀. Ups. fw. resembles *narcissus* Butl. in that the white area reaches inner margin but is less extended towards tornus; outer edge of white area not oblique as in *jacksoni*, and is toothed in areas 1*b* and 2. Hw. spots on veins 2 to 4 elliptical, larger than in other forms, about 1·5 mm. in diameter on the veins; spots on veins 5 to 7 usually confluent to form a black border. Uns. fw. with marginal spots larger than in other forms, being a trifle smaller than spots on hw. Hw. with all seven marginal spots very prominent as on ups. Specimens noted below from the Semliki and Ituri resemble *jacksoni* on fw. but are included here as possessing the enlarged marginal spots on both sides.

Habitat.—Uganda : Mabiri Forest, Mulange, 4000 feet, December, 1920 (*R. A. Dummer*) (♂ *type*); Chagwe, Mabiri Forest, 3500–3800 feet, 16–25.vii.1911 (*S. A. Neave*) (♀ *allotype* and another). Kenya : Kibwezi, 1 ♀. N.E. Congo : west Semliki Valley, escarpment, 20 miles S.W. of Boga, 3500–4000 feet, July, 1924 (*T. A. Barns*), 2 ♂; *id.*, June, 1924, 1 ♀; Ituri Valley, 30 miles south of Irumu, 3000 feet, July, 1924 (*T. A. Barns*), 1 ♂.

Mylothris sagala knutsoni Auriv. form **discus** form. n.

♂. Ups. fw. with white area reduced proximally, not reaching below the point of origin of vein 2; cell-streak reduced, being narrower and not reaching vein 2. Uns. as in the nom. form.

♀. Ups. fw. differs from typical female in the same way as does the male. Hw. with apical dark border as in the nom. form.

Habitat.—Western Cameroons : Kumbe, near Nigerian border, 5500 feet, October, 1921 (*G. L. Bates*) (♂ *type*); *id.*, Sept. and Oct., 1922 (*G. L. Bates*), 2 ♂, 4 ♀ (♀ *allotype*); Banso Mtns., north of Kumbe, 6000 feet, September, 1922 (*G. L. Bates*), 1 ♀.

The nom. *knutsoni* is represented in the British Museum by 1 ♂, 2 ♀ from Mt. Cameroon.

Mylothris sagala albissima subsp. n.

♂. Resembles *swaynei* Butl. from Abyssinia. Fw. with costal dark border narrow and at base not wider than in *crawshayi* Butl.; outer marginal border narrower than in *narcissus* Butl., reaching vein 5; marginal black spots, of moderate size and somewhat rounded, on veins 1 to 4. Hw. yellow with seven marginal spots.

♀. Resembles the male. Uns. hw. and apical area of fw. ochraceous.

Habitat.—N.E. Rhodesia: Mpika district, 4000 feet, March–April, 1921 (ex Coll. Joicey), 2 ♂, 2 ♀. Collected "among mulberry and similar trees." Collector not known.

Mylothris sagala sagala Gr.-Sm. form **seminigra** form. n.

♂. Ups. fw. with the four white stripes greatly reduced, especially the one in area 3; no white streak in the cell. Hw. with costal area yellow to vein 7; area from vein 7 to vein 3, including cell to base, black; a yellowish-white streak in areas 3 and 4, the latter one traversing the cell where it is sometimes vestigial. Uns. as in the nom. form.

♀. Not essentially different from the nom. form. Hw. somewhat paler in distal area; an indistinct dusky stripe in the cell along its lower edge.

Habitat.—Tanganyika Territory: Morogoro, June to August, 1922 (*C. J. Kirkham*), 4 ♂, 2 ♀.

Mylothris bernice rubricosta (Mab.) ♀ form **fuscescens** form. n.

Ups. smoky-white to dusky grey; in paler specimens an outer dark border to fw. is defined; cilia white to yellowish-white. In 4 specimens from the Kivu region the forewing bears well-defined marginal yellowish spots or streaks.

Habitat.—Eastern Congo: Urundi district, August, 1925 (*T. A. Barns*) (*type* and 2 others); N.W. Kivu (*T. A. Barns*), four; Ruanda, 8.vi.1916 (*G. D. H. Carpenter*), one, noted in *Proc. ent. Soc. Lond.* **1916**: cxxiv (Hope Dept.). Western Uganda, March and April (*E. Barns*), one; Kigezi district, March (*C. E. Longfield*), one. Kasai River, Dima, one. Tanganyika Territory: Usambara, two (not darkened on underside and lighter on upperside).

Mylothris bernice attenuata subsp. n.

♂♀. A slightly differentiated form in which the basal red stripe is little wider at base than on costa, usually not extending to midway along lower margin of cell.

Habitat.—S.E. Congo: Lufira River, 3500 feet, May and July (*S. A. Neave*), 1 ♂, 2 ♀; *id.*, 1 ♂ (Hope Dept.); Upper Lualaba River, 3500–4000 feet, 23.v.1907 (*S. A. Neave*), 3 ♂ (Hope Dept.). Nyasaland: Zomba (*Gosling*), 2 ♂, 6 ♀; Lake Nyasa, 10.x.1936 (*F. Zimmer*) (*type* ♂ and another); Central Angoniland, 4000–5000 feet, 28.v.–3.vi.1910 (*S. A. Neave*), 2 ♂, 1 ♀; Zomba Plateau (*H. Barlow*), October, 1919, 1 ♀. N.E. Rhodesia: Sept., 1910 (*S. A. Neave*), 1 ♀; Fort Jameson, June, 1910 (*S. A. Neave*), 1 ♀; Chambezi River, July, 1917 (*T. A. Barns*) (*allotype* ♀). East Loangwa District, 3000–3500 feet, March and May (*S. A. Neave*), 1 ♂, 1 ♀ (Hope Dept.); Lake Bangweolo, Chishi Island, 3800 feet, June and July (*S. A. Neave*), 1 ♂, 2 ♀ (Hope Dept.).

(F) Revisional Notes on the Species.

Mylothris similis Lathy (1906) and *M. dollmani* Riley (1921).

A male of *dollmani* from Rhodesia, 2 males of *similis* from Nyasaland (Mlanji), and a male of *similis* from Zanzibar were dissected. The harpe (pl. 1 fig. 4) consists of a long and relatively broad lobe of triangular shape, having a flattened apex. This is rather different from the harpe found in other species examined. In one of the Mlanji specimens the harpe is shorter and broader, especially broader at the apex. This specimen was one of the

original *similis* series from the Adams Collection; it cannot be separated from other Mlanji specimens, and in the other one dissected the harpe is, apparently, only slightly broader than in *dollmani*. It seems necessary, therefore, to consider these forms as being conspecific.

The female of *similis* may be easily mistaken for the female of *rueppellii rhodesiana* Riley which occurs with it. In the latter the edge of the fw. apical black border is even; in the former this edge is toothed on vein 6. Usually, also, the spot on vein 5 in *similis* is smaller and not entirely merged with the apical border.

Mylothris nagaziya (Ob.) ♂ f. *humbloti* (Oberthür) (1888).

An examination of the type reveals that *humbloti* is a melanic example of *nagaziya*.

Mylothris phileris (Boisd.) (1833).

The Oberthür Coll. contained a large series including 2 males ex Coll. Boisduval. One of these, with smaller marginal spots, agrees fairly well with the fig. of male (in Boisd. 1833); it agrees also with description in having fw. yellow at the base on ups. This specimen is now selected as type. No female specimen from Coll. Boisd. was found in Coll. Oberthür.

Mylothris chloris (Fabr.) and *M. agathina* (Cram.).

Some years ago the late Dr. F. A. Dixey arranged a series of these insects, in the Hope Dept. at Oxford, to illustrate his theory that *chloris* and *agathina* were conspecific. The series arranged by Dr. Dixey shows all transitional phases, in both sexes, from the broadly black-bordered *chloris* form through *clarissa* Butl. and *wintoniana* Shpe. to typical *agathina*. These various forms are present also in a series of twelve, in the Hope Dept., from the northern province of Uganda.

A similar series of forms is contained in the British Museum.

These specimens, the known distribution, and the similarity of the harpes (pl. 1 figs. 8, 9) in typical *chloris* and *agathina*, appear to confirm Dixey's theory.

Mylothris chloris chloris (Fabr.) (1775).

f. *richlora* Suffert (1904).—This form has the hind-wing spots usually large and more or less connected on ups.; uns. spots usually connected to form a narrow marginal band. The female associated here with it is ochraceous. Hw. with a continuous marginal border as in *clarissa*, but narrower, being about 4 mm.

Described from Niam-Niam in the region of the White Nile. A ♂ from the Cameroons is in the British Museum.

f. *analis* Auriv. (1907).—This appears to be similar to *richlora*. Fw. marginal border reaches vein 3. Hw. as in *agathinoides* or with enlarged spots merged together in a narrow marginal border. In Congo specimens the inner area has some yellow suffusion. The female, as described by Aurivillius (1910), is very similar to that of *richlora*.

♀ f. *intermedia* Auriv. (1910).—Two specimens in the British Museum may belong to this form. One is nearly typical (*vide* Seitz, *Macrolep.* **13**, t. 12*c*), but with far more extended dusky scaling on fw. The second specimen is less dusky, the dark scaling occurring chiefly over the anterior third of wing;

basal area dull red. Hw. spots all free; wing only slightly darkened. Uns. resembles the form *ochreata* but the hw. is paler.

In the southern Sudan there is an overlap of the subspecies *chloris* and *clarissa* with a mixture of forms including also *richlora* and *agathinoides*, but typical *chloris* appears to predominate.

Mylothris chloris clarissa Butler (1888).

Both wings with marginal borders much narrower than in typical *chloris*. Fw. usually white, and hw. usually ochraceous, on both sides. Associated with this type of female are males with similarly narrow marginal borders.

Within the area of this subspecies eleven forms occur, with f. *clarissa* predominating, viz. :—

1. f. *clarissa* Butl.
2. f. *chloris* (Fabr.). Occurs rarely. Uganda, district of Mt. Elgon, 6 ♀, 1 ♂.
3. f. *analis* Auriv. Rare. Uganda, 2 ♂, 1 ♀.
4. f. *richlora* Suff. Uganda, 9 ♂; Kenya, 2 ♂, 1 ♀.
5. f. *agathinoides* Talb. Uganda and Kenya, 23 ♂, 1 ♀.
6. ♀ f. *nox* Talb. One from the " Congo."
7. ♀ f. *ochreata* Talb. Uganda and Kenya, 9 ♀; S. Sudan, one.
8. ♀ f. *rubrochracea* Stoneham (1937).

Resembles *richlora* ♀ but is more deeply ochraceous. Fw. ups. with basal orange-red usually intense.

Described from Trans-Nzoia. 4 ♀ Uganda.

9. ♀ f. *wintoniana* Sharpe (1891).

Ups. fw. with marginal spots on veins 2 and 3 free and also often the spot on vein 4. Hw. spots large excepting the one on vein 1*b* which is always small and well separated from the spot on 2; spots on 2 to 4 usually free, those on 5 and 6 merged to form an apical band. Both wings may be white or the fw. white and hw. yellow, or both wings yellow, resembling *rubrochracea*.

In the British Museum a small series from Uganda and Uganda–Kenya border.

10. f. *agathina* (Cram.). Occurs in small numbers in the northern part of the area. Specimens are in the British Museum from Mabera Forest, Ungoro, E. Mbale, Entebbe, S. Buddu, Mulema, Lusinga Is., Nyanza Prov., Lumbwa, Eldoma Ravine, Mt. Elgon, Kikuyu Escarpment. Also 1 ♂ from southern Sudan. A species described from Trans-Nzoia as *afraorientalis* Stoneham (1937) appears, from the description, to be only *agathina*. The description is not comparative and applies very well to normal specimens of *agathina* (♂♀).

11. ♀ f. *ochrasiens* Stoneham (1937). Described as a female form of *afraorientalis* from Cherangani, east of Mt. Elgon. This appears to represent the strongly ochraceous female of *agathina*.

Mylothris chloris agathina (Cram.) (1779).

This subspecies is rather constant throughout its wide range. There is an overlap in western Kenya (east of the Rift) where forms occur (though rarely) that are peculiar to the central subspecies.

Besides the typical *agathina* male the following five forms are known within the range of the subspecies :—

1. f. *agathinoides* Talb. Nairobi, 1 ♂; Kibwezi, 1 ♂.
2. f. *clarissa* Butl. Kibwezi, 1 ♂; Mt. Kenia, 1 ♀.
3. f. *wintoniana* Shpe. Nairobi, 2 ♀.
4. f. *ochrasiens* Stoneh. The normal yellow ♀.
5. f. *leucoma* Talb. Tanganyika Territory; Congo; Angola; S. Africa.

Gynandromorph.—

Ups. fw. female (ochraceous). Hw. mostly male (white). Left hw. with inner area ochraceous to cell and vein 3, leaving a small space of white in base of area 2; in area 4 an ochraceous streak bordering vein 5 from margin to near cell where it is narrower. Uns. of both wings ochraceous as in most females.

The genitalia are, apparently, largely female, but there is at least one valve fully developed.

Habitat.—Malvern, Natal (*C. N. Barker*) (ex Coll. R. Trimen).

Mylothris rembina (Plötz) (1880).

This species is closely allied to *chloris* (Fabr.) as shown by its facies and by the form of the harpe (pl. 1 fig. 10). It was described from 2 females from the Rembo River, near Mungo, in western Cameroons.

The following forms are known :—

1. ♂ f. *subfusa* Crowley (1890).

Ups. fw. with marginal border to vein 4. Hw. with marginal border from inner angle to vein 4, with marginal spots on veins 5 and 6, or this band broken up into spots. Uns. fw. with marginal border to veins 5 or 4. Hw. marginal border continuous and solid, or formed of rounded conjoined spots.

The name *aneria* Hulstaert (1924) is founded upon a specimen with narrower border on hw. uns., and hw. ups. bearing marginal spots.

2. ♂ f. *arctata* Talb. (p. 167).
3. ♀ f. *rembina* (Plötz).

Ups. both wings dusted with blackish-grey, the white gr.-col. only appearing near inner margin of fw. and at innner margin of hw. Uns. fw. dusted with blackish-grey but to a less extent than on ups. Hw. with marginal border reaching cell or beyond; basal area entirely, or in part, thickly dusted with blackish-grey.

This form is chiefly distinguished by the darkening of the fw. uns.

There is no typical *rembina* among the 33 females of the species in the British Museum.

4. ♀ f. *infuscata* Bartel (1905).

Ups. fw. with a p.-d. white area usually extending from cell to the outer wide dark border which is usually well defined. Hw. with a marginal broad dark border, extending to near or into the cell; basal area strongly dusky. Uns. fw. grey-white, not dusky as in *rembina*; marginal dark border of variable extent, reaching vein 4 or vein 2. Hw. border as on ups. but basal area usually much less dusky.

5. ♀ f. *fusca* Bartel (1905) (= ♀ *semifusca* Crowley, 1890, pl. xviii, fig. 4).

Ups. darker than in *infuscata*. Fw. as in f. *rembina*. Hw. with indistinct marginal border, somewhat darker than the gr.-col., continuous from inner angle to apex, and not wider than in most males. Uns. white or yellowish. Fw. marginal border narrower than in

infuscata; marginal spots on veins 2 to 4 or 5. Hw. marginal border as on ups., about 3 mm. wide, evenly and sharply defined; the wing often more or less dusky (nom. specimens).

6. ♀ f. *semifusca* Talb. (p. 167).

Mylothris citrina Auriv. (1898).

This insect is treated provisionally as a species. It is, apparently, allied to *sulphurea* Auriv., and *ochracea* Auriv. It differs from these and similar forms in that the fw. marginal spots on veins 2 to 5 are free, the one on 2 being only a dot.

Mylothris sulphurea Auriv. (1895).

It seems necessary to unite under *sulphurea* a number of forms previously considered to represent species. The material examined, both in the British Museum and in the Hope Dept., Oxford, seems to indicate the existence of three subspecies and some individual rare forms.

The forms *sulphurea*, *dimidiata*, *basalis*, *primulina*, *solilucis*, and *pallescens* have been dissected. The slight differences in form of harpe are not such as to warrant the separation of any of these forms as distinct species. There is a resemblance to forms of *chloris* but the type of harpe (pl. 1 figs. 11, 12, 13) is different. The lobe is broad with a lateral protuberance of varying convexity; in lateral view the apex of lobe appears rounded, but a vertical view shows it to be distally pointed with a slant proximad.

The female of *sulphurea* is extremely rare in collections. The first was described by Gaede (1916). A specimen in the British Museum from the Cameroons agrees with Gaede's description. Another specimen in the British Museum from the Gaboon belongs to *basalis* and is described below.

Ups. white. Fw. apical border as in male but merged with a large round spot on vein 4; a large spot on vein 3, and the usual spot on 2 free. Hw. spots as in the male. Uns. as in male but basal sulphur-yellow more restricted.

Mylothris poppea (Cramer) and *M. rueppellii* (Koch).

These are both characterised by having the basal area of fw. ups. orange-red or orange-yellow.

In typical *poppea* the fw. marginal spot on vein 3 is very rarely separated from the marginal border; in the subspecies *hilara* (Karsch) this spot is often free, and such specimens approximate to *rueppellii* forms; some specimens of *hilara* have the basal area orange-red as in *rueppellii* forms.

In typical male *poppea* the hw. marginal spots are prominent on both sides. In *hilara* and forms of *rueppellii* these spots are minute on ups. and on uns. are smaller than in *poppea*. Fw. uns. with a basal yellow area similar in all forms, but in *rueppellii* forms it is of greater extent.

In typical female *poppea* the fw. marginal border is very broad and formed of a series of black vein-stripes, rarely entirely coalescent, somewhat resembling *rhodope* female in which, however, the tornal spot is absent or vestigial. Hw. marginal spots very large and rounded.

In *hilara* the female resembles the male, with basal yellow area on ups. reduced, and resembling some *rueppellii* forms.

In a Uganda subspecies, where the male is, apparently, not different from true *poppea*, the female is unlike any *rueppellii* form. Fw. with a solid marginal

border as in the male, the tornal spot being small or minute as in *hilara* and *rueppellii*. Hw. marginal spots larger than in the two latter forms, but smaller than in true *poppea*.

Genitalia (pl. 1 figs. 14, 15).—In both groups of forms the harpe is very similar. In *poppea poppea* it is produced to a broad finger-like lobe having a ventral bulge. In *poppea hilara* the harpe is bilobed, the secondary lobe being much shorter; a similar harpe is found in all *rueppellii* forms with slight modifications in subspecies. It is, perhaps, significant that in the form *erlangeri* Pagenst. the harpe more nearly approaches that of *poppea poppea*.

Dissections of all the forms have been studied.

Distribution is also significant. The *poppea*-like forms are found in West Africa, the eastern Congo and Uganda. The *rueppellii*-like forms are found from the Cape to Kenya, Sudan and Abyssinia, extending westwards to Angola and sparsely into Uganda.

It is to be noted that, according to material in the British Museum, the *poppea*-like Uganda subspecies is much commoner in Uganda than *tirikensis*, which is essentially a Kenya race.

The form *hilara* occurs rarely in Guinea and in Sierra Leone, there being two males from each area in the British Museum.

The form *alcuana* Grünb., which approximates more to *rueppellii*, appears to be very rare. Described from Spanish Guinea, it is in the British Museum from Togoland (2 ♂), and Accra (1 ♀).

The conclusion reached, by the foregoing considerations of the facies, genitalia, and distribution of the forms, is that *poppea* and *rueppellii* are conspecific.

Mylothris poppea hilara f. *alcuana* Grünberg (1910).

Described from 2 ♀ from Spanish Guinea.

Ups. appears to resemble *dubia* Auriv. in having a similar marginal black border on fw.; basal area dull ochraceous to beyond middle of cell. Uns. of fw. with basal area dark chrome-yellow.

A ♀, apparently of this form, labelled "Accra (Crowley Coll.)", is in the British Museum (N.H.); 2 ♂ from Togoland (ex Coll. Oberthür) are probably associated with it; these, like the female, have extended basal yellow on fw. ups., and in other respects resemble *hilara*. The harpe of this form is much the same as in *hilara* and *continua*.

The name *excavata* Strand (1913), given to one of the two females described by Grünberg, appears to represent a phase slightly transitional to *hilara*.

Mylothris poppea rueppellii (Koch) (1865).

The Abyssinian subspecies is only slightly differentiated from the form occurring in Kenya and Uganda. It is distinguished by the ups. being slightly tinged with yellow. Similar yellowish specimens occur in Kenya (f. *kenia* Rly.), and white specimens, with pale orange basal area, occur in Abyssinia in a small minority. A few typical *rueppellii* are more strongly yellow, and so bridge the gap between the f. *rueppellii* and f. *erlangeri* Pagenst. The females of these two forms are very similar, and both agree in that the basal area of fw. on ups. is of a duller orange and of less extent and less well defined than in the southern subspecies. Females that are more yellowish or pale ochraceous are assigned to *erlangeri*. The white females, usually with a creamy or dull yellowish tinge, are placed under f. *rueppellii*; *kaffana* Riley (1921) is a

synonym of this form. The yellow *erlangeri* seems to be more frequent than the other, at least in west and central Abyssinia.

Mylothris poppea tirikensis Neavé (1904).

This is the oldest name for the subspecies ranging from Uganda to Kenya and northern Tanganyika Territory. The name was based upon a female in which the basal area of fw. on ups. was strongly dusted with black.

♂. Ups. white. Fw. apical border of varying width, from 0·5 mm. to 3 mm. on vein 6; in a specimen from Mt. Elgon the border is about 5 mm. on vein 6, and is continued more narrowly to vein 3; orange-red basal area somewhat rectangular and well defined. Hw. with more or less yellow basal suffusion. Uns. fw. with marginal spots usually more weakly marked than in Abyssinian specimens.

♂. f. *aspilota* Hulst. (1924). Ups. fw. with marginal spots absent or present as dots; apical black very narrow and not reaching vein 5.

♂ f. *kenia* Riley (1921). Ups. tinged yellow. ♀. Ups. resembles the male. Fw. basal red duller and often more or less dusted black. Uns. as in the male except that gr.-col. is usually creamy-white instead of chalky-white.

♀ f. *kikuyuensis* Bartel (1905). Ups. hw. with a small basal area orange-red; the usual form.

Mylothris poppea hilara (Karsch) (1892).

Type a ♂ from the Cameroons. Approximates to *rueppellii* forms. Specimens are in the British Museum from N. Nigeria (Ropp), the Cameroons mountains on Nigerian border, and from other areas in the Cameroons; also from the eastern Congo and the Katanga.

According to Strand (1912 : 138) the ♀ figured by Aurivillius in 1910 (Seitz, *Macrolep.* **13**, t. 10*e*) is not like the ♀ type, the typical female being *continua* Auriv. (1910). As stated above, the type of *hilara* is a male. The specimen figured by Aurivillius belongs to *rhodope* (Fabr.). The female of *hilara* is similar to the male.

The name *limbonotata* Strand (1913) refers to a minor form with more prominent marginal spots on hw. above.

The name *conflua* Strand (1913) refers to specimens with confluent apical spots on fw. uns. This variation is liable to occur in most species. It is seen in some females of *hilara* from the Congo.

♀ f. *dubia* Auriv. (1907). Rare. In the British Museum a single specimen from the Oubangi. Similar to Uganda specimens, but with a yellowish tinge on both sides. Hw. marginal spots above not larger than in Uganda males.

Mylothris poppea hilara ♂ f. *asphodelus* Butl. (1888).

Described from the Cameroons. No female has been associated with this form. Resembles *poppea* and *continua*, having the broader marginal border of the latter race. The sulphur-yellow basal area is sometimes tinged with orange on both sides, in Uganda specimens especially on uns.

Occurs apparently with equal frequency in the Cameroons and Uganda. Harpe as in *continua*.

Mylothris poppea continua Auriv. (1910).

The name is based upon a female.

♂. Ups. fw. with marginal border tending to be wider than in the nom. subspecies, usually exceeding 4 mm. at vein 5, *poppea* averaging about 4 mm. In other respects this

resembles the nom. form. Uns. fw. with apical spots sometimes confluent (f. *confluа* Strand).

It may be noted that the male of *M. rhodope uniformis* Talb., from the same area, has similarly diverged only slightly from its more western form, the female in both cases being quite different.

♀. Ups. white. Fw. with a basal yellow tinge as in *hilara*; marginal border to vein 2 broader than in *hilara*, and usually with indistinct yellow stripes between the veins, reminiscent of *rhodope* forms; inner edge of marginal border usually incurved but sometimes almost straight; tornal spot varying in size and sometimes absent. Hw. marginal spots large, much more prominent than in *hilara*. Uns. fw. white, with apical spots sometimes tinged ochraceous; apical spots sometimes confluent. Hw. white but usually tinged ochraceous.

Habitat.—UGANDA. In the British Museum from the Mabiri Forest; Buddu; Mt. Elgon district; Entebbe; Jinja; Kampala. ♂ *neallotype*, Mabiri Forest, Chagwe, 3500–3800 feet, 16–25.vii.1911 (*S. A. Neave*).

Mylothris flavicosta Rebel (1914).

Appears to be a distinct species allied to *poppea*. Fw. with a yolk-yellow costal border, with similar colouring along inner side of outer marginal black and along veins 2 to 5. Uns. fw. darker yolk-yellow, more orange basally. Hw. with basal costal orange, and yolk-yellow along anal-fold. All marginal spots much smaller than in *rhodope*.

Considered by Aurivillius (Rebel, 1914 : 225) to be possibly the male of *dubia* Auriv.

Mylothris yulei Butler (1897).

The evidence of genitalia, facies, and distribution suggests that *yulei* is conspecific with *rhodope* (Fabr.). The harpe (pl. 1 fig. 17) is similar in both, with similar variations, being almost identical with the usual *rhodope* type having the shorter lobe well developed and curved, the other somewhat spatulate.

It is probable that over a small part of their range (*e.g.* Cameroons) *rhodope* and *yulei* do not interbreed but possibly do so over the greater part. In the former case they will exist as two species; in the latter case they will exist as subspecies of a single species.

M. yulei appears to be partial to drier areas. It occurs in Abyssinia where *rhodope* is absent, but both occur together in the Cameroons, *rhodope* being much the commoner; also in Uganda where *rhodope* is in great superiority over *yulei*. On the other hand, in Kenya, where *yulei* is common, *rhodope* is rare, being apparently absent from eastern Kenya, Tanganyika Territory, and Nyasaland.

The species is distinguished by the small marginal spots and narrow border on fw., this border usually not reaching below vein 4. Most specimens have the hw. uns. and apical area of fw. pale yellow or chrome. Five subspecies can be distinguished.

Mylothris yulei amhara Ungemach (1932).

This, the Abyssinian subspecies, has the facies of *yulei*, but the harpe resembles certain *rhodope* forms rather than any other *yulei*. The female is essentially of the *yulei* type. I formerly considered it as belonging to *rhodope*

(*in* Carpenter, 1935, *Rhop. Abyss.* : 335) and still consider that this view may be partly correct.

Mylothris yulei latimargo Joicey & Talbot (1921).

♂. Ups. fw. with marginal border narrower than in *yulei* from Nyasaland, and only reaching vein 4 in a small proportion of individuals (7 out of 22 in the British Museum); with rare exceptions a short streak of ground-colour invades the margin on vein 8; basal area usually only tinged with yellow, but in some males from Kisii (W. Kenya) the area is strongly yellow. Hw. marginal spots absent or vestigial, rarely developed as in Nyasaland specimens.

♀. Resembles the male. Fw. border slightly wider and only reaching vein 4 in one out of seven examples. Uns. with a yellow tinge to hw. and apex of fw. Hw. marginal spots developed.

Habitat.—Western Kenya, a series of males and 6 ♀ in British Museum. Uganda, Buddu, Tero Forest, 1 ♀. Eastern Congo, Urindi district, 1 ♂ (in Hope Dept.). S.E. Congo, 150 to 200 miles west of Kambove, 3500–4000 ft., 1.x.1907 (Coll. Neave), 1 ♂, 1 ♀. N.E. Rhodesia, Luena River, 8.ix.1904 (*R. L. Harger*), 1 ♂.

The Kambove ♂ is entirely without yellow tinge on uns. The ♀, bearing same data as ♂, has ups. fw. creamy-white with a yellow tinge over outer margin; marginal spots on veins 2 to 6, those on 5 and 6 elongate; apical black of small extent from area 6 to 7. Uns. with the usual yellow tinge.

The Rhodesian ♂ resembles some Kenya specimens on ups., the short apical border being wider than usual. Uns. of hw. and apex of fw. with a paler yellow tinge than is usual in Kenya specimens.

Mylothris yulei ertli Suffert (1904).

♂. Ups. fw. with apical border wider than in *latimargo* and as in *yulei*, usually not reaching vein 4 and always including the spot on vein 5; rarely a streak of gr.-col. invading the margin on vein 8; basal area pale orange and much more conspicuous than in any *latimargo*. Hw. marginal spots present (in all specimens examined); basal area pale orange but of less extent than on fw. Uns. marginal spots prominent. Fw. with or without apical yellow tinge; basal yellow extended to beyond middle of cell, being of much greater extent than in *latimargo*. Hw. with or without a yellow or creamy tinge.

♀. Resembles the male but marginal spots larger; upperside basal yellow paler and sometimes more extended.

A ♂ paratype from Ukerewe, and the ♀ allotype of *yulei* from Kilimanjaro, are in the British Museum.

Mylothris yulei yulei Butl. (1896).

♂. Ups. fw. with marginal border as in *ertli* (3·5 to 4 mm. wide on vein 6) and reaching vein 4; no streak of gr.-col. invades the margin on vein 8; basal area either without yellow (typical) or with yellow not more prominent than in any *latimargo*. Hw. marginal spots as in *ertli*; basal yellow vestigial or absent. Uns. marginal spots as in *ertli*. Fw. yellow not more extended than in *latimargo*; apical area white or with yellow tinge. Hw. white or with creamy or yellow tinge (f. *sulphurascens* Hulst.).

♀. Ups. more creamy-white than in *ertli*. Fw. basal pale yellow extended as in *ertli* but not outwardly defined; apical area with a yellow tinge, the edge of apical border less sharply defined than in *ertli*. Uns. as in male except that the hw. and apical area of fw. are pale ochraceous. Only one female seen.

Habitat.—Nyasaland: Chintechi, 1 ♂ (typical); Limbe, 1 ♂ (typical); ? Songwe Plain, N.W. Nyasa, ♂ type; Mlanji, 2 ♂ (with basal yellow). S.E. Congo: Lake Mweru district, Luvua Valley, 1 ♂; Lualaba River, 1 ♂; Katanga, 2 ♂; Kikura River, Lifura Valley, 1 ♀ (allotype of *latimargo*).

One of the Katanga males is very similar to the *latimargo* form *rhodopoides*.

Mylothris rhodope (Fabr.).

This species exhibits a certain constancy of pattern in the male which is variable within small limits. On the other hand, the genitalia (pl. 1 figs. 18–23) show unusual variability. The harpe is usually bilobed, resembling that of most *yulei*; the ventral lobe is subject to reduction and may be entirely absent. These forms of the harpe are not always correlated with a particular wing-pattern, though in some localities specimens having a narrow fore-wing border are found to possess a single-lobed harpe. This is well demonstrated on Fernando Po. Here two forms of each sex can be distinguished. (1) ♂♀ identical with nominotypical *rhodope*, with harpe bilobed (pl. 1 fig. 18). (2) Form *fernandina* Schultze, in which the marginal black is somewhat narrower, and female white; harpe with a single lobe (pl. 1 fig. 20). This form occurs in other areas where it approximates more to the nominotypical one in respect of wing-pattern. This is illustrated by the following examples of specimens dissected :—

Gold Coast, 3 ♂. One has a single-lobed harpe, the others having it bilobed. All with similar facies of the wet-season type.

Cameroons, 6 ♂. One has a single-lobed harpe (pl. 1 fig. 23), one has the ventral lobe narrower and shorter, the others have the harpe normally bilobed (pl. 1 fig. 22). Fw. border narrow to broad, the specimen with single-lobed harpe having a border of intermediate width.

Uganda, 10 ♂. Four of these have a single-lobed harpe. Wing-pattern very similar in all specimens, one with the narrowest marginal border having also the harpe bilobed.

It is possible that this variation is connected with the evolution of seasonal forms. Two such forms may be diagnosed as provisional. A wet-season form in which the male has the fw. border wider, the hw. marginal spots prominent, and the female with an ochraceous fw. A dry-season form in which the male has the fw. border obviously narrower, the hw. marginal spots smaller, and the female white, approaching the male in pattern. In the eastern subspecies both forms have a white female.

Mylothris rhodope rhodope (Fabr., 1775).

Form *rhodope* (Fabr.).—Male designated by Aurivillius as *spica* Möschl. in Seitz, *Macrolep.* **13**, t. 10*d*.

Ups. fw. with marginal border reaching vein 3, the spot on 3 small; vein 2 with spot vestigial or absent.

♀. The type specimen is from Sierra Leone, and is in Coll. Banks, but was not examined by me. It is figured in Donovan (1824), the name *donovani* Holland (1920) being based on this figure. The figure represents a rare form in which fw. marginal black border is heavily marked and strongly dentate. There is a specimen very near this in the British Museum from the Belgian Congo, in which fw. is paler ochraceous, the posterior three spots free, and all the spots triangular. Also a similar specimen from the Gold Coast, having fw. typically deep ochraceous.

♂ f. *schumanni* Suffert.

Ups. fw. with marginal border tending to be narrower and typically ending in a point (not a spot) on vein 3; hw. spots smaller. Harpe with ventral lobe vestigial or absent (pl. 1 fig. 21).

♂ f. *hintzi* Strand = *spicatana* Strand (1913, Cameroons).

A large form in which fw. border reaches just below vein 2; fw. length about 30 mm.

♂ f. *spicatella* Strand. This name was founded upon one specimen.

Fw. border, relatively to size of insect, wider than in other forms, its edge straight.

♀ f. *eudoxia* (Boisduval). This appears to be the most prevalent form.

Fw. ochraceous; marginal streaks heavy, and apical black suffusion more or less developed.

♀ f. *spicana* Strand.

Similar to *eudoxia* but marginal vein-streaks much thinner. Although a male was included in the diagnosis the name was based upon the female.

♀ f. *caspi* Suffert = ♀ *flavicosta* Neustetter (*non* Rebel) (1913).

Fw. pale to dark ochraceous, with black dusting over the whole marginal area; proximal edge of the border scalloped; on veins 2 and 3 are marginal spots instead of bars, on vein 4 a thick bar. Very close to f. *spica* Möschl.

♀ f. *spica* (Möschler).—The figure by Aurivillius in Seitz' *Macrolep.* (**13**, t. 10*d*) may be taken to represent this form. Similar to *caspi*.

Fw. border defined by marginal and proximal black edging, the veins crossing this area heavily blackened. Not common.

In the British Museum from the Haute Volta, Gold Coast, Nigeria.

♀ f. *beethoveni* Suffert.

Fw. ochraceous; a small apical dusky area, rarely well defined as in the type, and usually inwardly diffuse.

♀ f. *pseudohilara* Strand = *hilara* Auriv. ♀ (*non* Karsch), in Seitz' *Macrolep.* **13**, t. 10*e*.—This is the white form which was formerly associated with *poppea hilara*.

f. *fernandina* Schultze.

♂. Fw. border narrower than in f. *rhodope* from the same place, its edge regularly incurved (a character found also in f. *rhodope*), reaching vein 3; a small spot on vein 2. Uns. with basal area sulphur-yellow, more restricted than in other forms and absent in some specimens. Harpe a single lobe (pl. 1 fig. 20).

♀. Ups. white with slight yellowish tinge. Fw. border of dark vein-streaks as in the ochraceous forms, with or without a black inner edging or black dusting. Hw. marginal spots smaller than in other female forms. Uns. as in male but with a yellowish tinge.

4 ♂, 4 ♀ in the British Museum. Also both sexes in the Hope Dept., Oxford. Only known from Fernando Po.

Mylothris mortoni Blachier.

Apparently a quite distinct species allied to *rhodope* (Fabr.). Its distinctive facies is accompanied by a distinct form of harpe (pl. 1 fig. 24). This is bilobed; dorsal lobe

longer than in any *rhodope* or *yulei* form, somewhat as in *amhara* but more pointed and narrow; ventral lobe short and narrow as in *amhara*.

The type, figured by Blachier, is a ♂ and not a ♀ as supposed by Ungemach (1932 : 22).

♀. Ups. milky-white. Fw. more or less reddish at base, usually with a basal costal stripe of dusky scaling; outer dark border wider than in male and reaching veins 4 or 3, the spots on 2 and 3 larger than in the male. Hw. marginal spots at least as large as in *rhodope* ♀. Uns. as in male.

Specimens of the form *balkis* Ungem. (1932) are in the British Museum from Central Abyssinia. Ungemach supposed this to form a western subspecies but on the evidence it seems best to treat it as an individual form.

sagala Group.

Only two species known, *sagala* Gr.-Sm. and *ruandana* Strand.

♂♀. Hw. yellow with seven marginal spots. Fw. costa black to the base.

Genitalia (pl. 1 fig. 25).—♂ valve rounded-triangular, without any distal projection. Harpe large, short, very broad, the lobe directed proximad.

Mylothris sagala swaynei Butl.

This form is curiously similar to *trimenia* Butl. from South Africa. Besides the type others from Abyssinia are in the British Museum from Djem-Djem Forest (*Scott*); Scioa, 1879–1880 (*Antinori*); Kollalis (*Ellison*).

In the western part of Abyssinia *swaynei* appears to be replaced by *jacksoni*; an overlap may exist in one area, as Ungemach (1932) records the ♀ of *swaynei* from the area of *jacksoni*.

Mylothris sagala jacksoni Sharpe (1891, Kavirondo).

This subspecies is distinguished by the extended black areas of fw., the inner margin always black. Variable, and includes the dark forms *neumanni* Shpe. and *striata* Auriv. A rare form, *insignis* Talb., with large marginal spots on hw., occurs here and there.

The type of *jacksoni* is in the British Museum and is a ♀ labelled " Kavirondo, Nov.–Dec., 1889 (F. J. Jackson) ".

Mylothris sagala narcissus Butl. (1888, Kilimanjaro).

This subspecies is distinguished by the extended white area on fw., inner margin not darkened.

♂ f. *aequimargo* Thurau.

Fw. outer border dentate as in *sagala*, and cell white as in *narcissus*.

Figured by Aurivillius in Seitz' *Macrolep.* **13**, t. 12*b*. The figure in Thurau (1903, t. ii, fig. 13) represents the form *dulcis* (*Berl. ent. Zeit.* **48** : 326).

♀ f. *dulcis* Thurau.

Fw. with cell white, only dusky at base.

One specimen in the British Museum, Mlanji Plateau, within the area of subspecies *sagala*.

♀ f. *decora* Thurau.—Described from a single specimen and distinguished by hw. being ochre-yellow.

Specimens, for the greater part not different in other respects from *jacksoni*, are in the British Museum from Mt. Kenia, also one from the Nyero River, and one from Toro, Uganda. Five of the eleven Kenya specimens have the *narcissus* type of fw., but males from the same area are all *jacksoni*. There is also one typical *decora* from northern Tanganyika Territory, taken by T. A. Barns in the Oldeani Crater, 9000 feet.

Distribution.—The subspecies *narcissus* is apparently confined to the coastal area of Kenya and part of Tanganyika Territory. In the latter region it occurs chiefly west of the eastern escarpment from Kilimanjaro and the Masai Steppe to the northern end of Lake Nyasa, where it overlaps the subspecies *sagala*.

Mylothris sagala sagala Grose-Smith (1886, Sagala).

A dark form with fw. cell entirely darkened or showing only a narrow streak of white. Male with distal white area usually broken up into stripes of variable length and width. Female very similar to that of *narcissus* but fw. marginal dark border wider and not usually interrupted by streaks of white reaching the margin.

A very dark, and otherwise distinct, form, *seminigra* Talb., occurs in the mountainous region of Morogoro, the ♀ approximating to *sagala*.

Distribution.—Tanganyika Territory, east of the eastern escarpment, from Usambara and Zanzibar to the Mlanji Plateau south of Lake Nyasa.

Type ♂ in the British Museum, taken at Sagala, about 100 miles west of Zanzibar. This indication may be an error for the place of that name which lies on the east of Kilimanjaro.

Mylothris sagala dentatus Butl.

f. *dentatus* Butl.

Similar to lighter specimens of *s. sagala* but the white area of fw. is not broken up.

Only two males, the type and another from same place, are in the British Museum. The type is labelled " Kantorongondo Mtn., Nyika, west of Lake Nyasa, 5900 feet, 15.iv.1895 (E. Crawshay) ".

f. *crawshayi* Butl.—The male figured under this name in Seitz' *Macrolep.* **13**, t. 11*d*, belongs to *narcissus*. In *crawshayi* the fw. apical black area only reaches vein 4, there being marginal spots on veins 2 and 3.

♂ type labelled " Kantorongondo Mtn., Nyika, 5900 feet (E. Crawshay) ".

♀ type labelled " Nyankowa Mtn., 6500 feet, 9.iv.1925 (E. Crawshay) ". This specimen, the only female of *crawshayi* in the British Museum, differs from Mlanji specimens of *sagala* in having the fw. dark border wider, teeth on the veins shorter, and white area extending into outer part of cell.

Habitat.—Known only from Northern Nyasaland, Nyika district.

Besides the types of *crawshayi* there are only four other males (paratypes) of this form in the British Museum. Our knowledge of the subspecies has not increased since the British Museum received the first specimens in 1896.

bernice Group.

This group is represented by a single species.

♂♀. Ups. fw. with a basal red stripe extended along costa; five small free marginal spots. Hw. with six very small marginal spots. ♂ valve (pl. 1 fig. 26) a rounded oval

without any distal apical projection. Harpe similar to that of the *sagala* Group, the lobe very broad and rounded.

Mylothris bernice bernice (Hew.) (1866, Gaboon).

♂♀. Ups. fw. with an apical and marginal dark border. Marginal spots of hw. and on uns. somewhat larger than in other subspecies especially in the female. Female more or less dusky white.

♀ f. *pallescens* Gaede (1916, Cameroons).

Ups. dull white without dusky scaling. Fw. marginal border more or less broken up into large elongate spots.

Mylothris bernice rubricosta (Mabille).

The figure of the type given by Mabille and Vaillot (1892) is said to represent a male. It is most probably a female, especially as the ups. is described as being yellowish-white. The insect may have been taken in the northern part of Mozambique, but there seems to be no later confirmation of its occurrence so far south.

f. *berenicides* Holland.

♂. Ups. fw. with an apical black area which may reach vein 3, or with prominent marginal spots on veins 2 to 5. Hw. marginal spots usually well developed.

♀. Resembles f. *pallescens*. Fw. with narrow elongate marginal spots and usually some apical black. A ♂ from the Itoa River, north-east Congo, is very close to nom. *bernice*.

The female occurs in three forms: (1) similar to the male, (2) dusky as in nom. *bernice* f. *fuscescens* Talb., (3) similar to either (2) or (3) but with yellow tinge above, *sulphureotincta* Strand.

♀ f. *sulphureotincta* Strand.—This was described as a male, but the coloration and the elongate marginal spots suggest that it is a female.

Genus *Pseudomylothris* Neust. (1929).

Neustetter, 1929, *Int. ent. Zeit.* **23**, no. 18 : 191 (type, *Mylothris leonora* Kruger).

This genus possibly forms a link between *Mylothris* and *Delias*. In both these genera the larva feeds on mistletoe (*Loranthus*); the pupae are also somewhat similar. The main distinction between *Mylothris* and *Pseudomylothris* is the absence in the latter of vein 10 of the fw., which is also the case in *Delias*. A good figure of the venation is given by Neustetter (*loc. cit.*). Vein 9 (most probably really $7 + 8 = R_4 + R_5$) is shown as going straight to the margin. In the paratype this vein curves slightly downwards near the apex of wing, but in the type it is as figured. The missing vein, therefore, is most probably 9 ($= R_3$) and not $7 + 8$.

P. leonora (Kruger), 1928.

♀. Ups. somewhat resembles *M. sagala* Gr.-Sm. Fw. marginal black area bears intraneural white streaks. Hw. pale yellow. Uns. chalky-white, hw. flushed with yellow in the type.

Habitat.—Tanganyika Territory, Ukami, Ulugum Mtns. The only specimens known are two females both of which are now in the British Museum (ex Coll. Joicey).

Corrigenda.

The following corrections to *Lep. Cat.* pt. 53 (Pieridae) may perhaps be suitably published here :—

Page 262. Möschler. For " 1883 " read " 1884 ".
265. *agathina*. For " pl. 257 " read " pl. 237 ".
265. For " *dolmanni* " read " *dollmani* ".
265. For " *crocea* " read " *croceus* ".
267. For *mortoni* " (1913) " read " (1912) ".
267. *phileris*. For p. " 17 " read " 165 ".
269. *swaynei*. For " 1896 " read " 1899 ". For " Somaliland " read " Abyssinia ".
269. *aequimargo*. For " 1904 " read " 1903 ". Transfer ref. to fig. to *dulcis*.
269. *decora*. For " 1904 " read " 1903 ".
269. *dulcis*. For " 1904 " read " 1903 ". Insert t. ii, fig. 13 (♀).
269. *Pseudomylothris*. Add 1929.

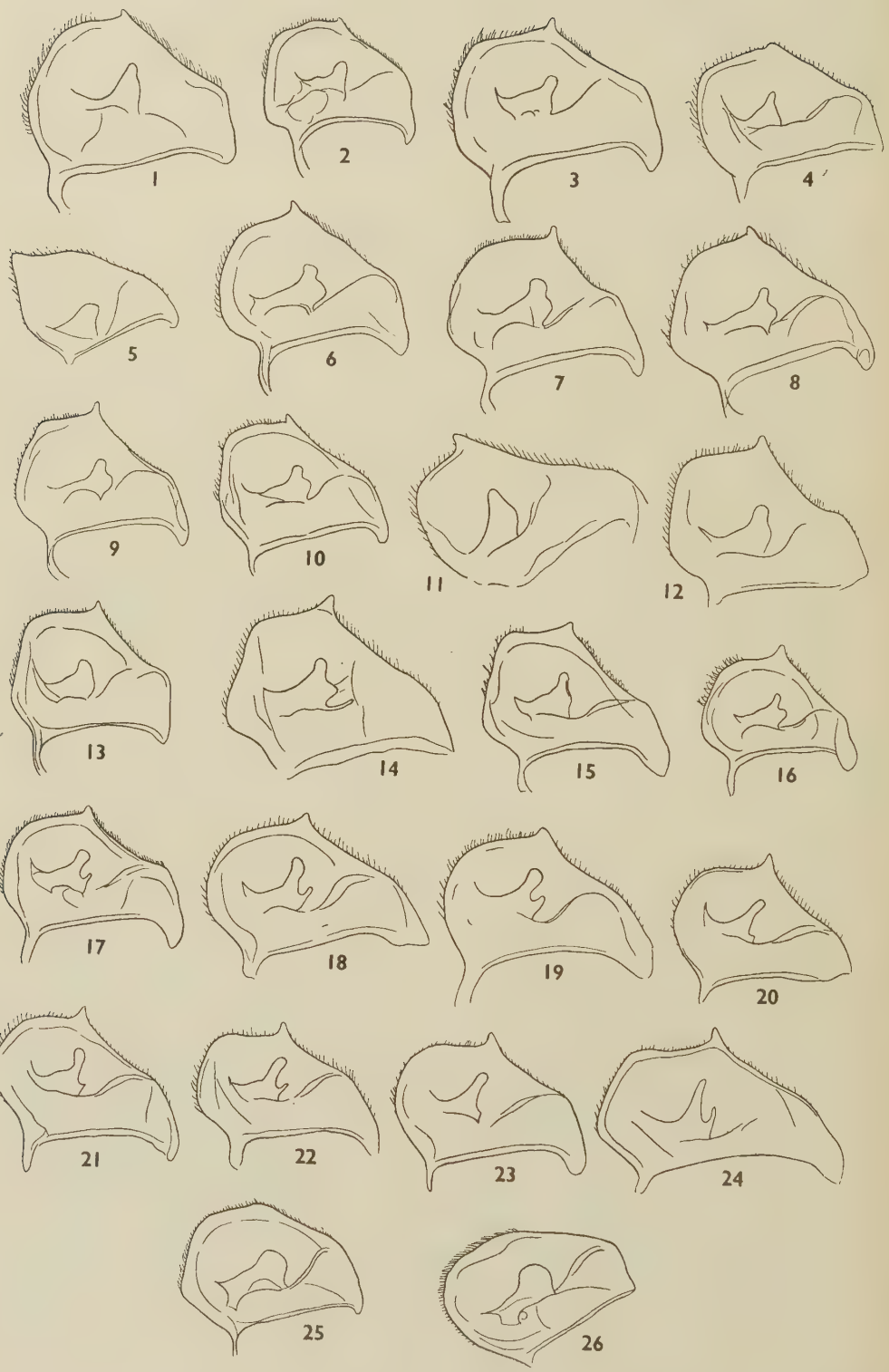
The dates of publication of the following names in the *Proc. zool. Soc. Lond.* are as follows :—Page 264, *asphodelus* (April, 1888); p. 265, *croceus* (April, 1896); p. 267, *yulei* (April, 1896); p. 269, *swaynei* (April, 1899). (See F. Martin Duncan, 1937, *Proc. zool. Soc. Lond.*, Series A, **107** : 71–84.)

Explanation of Plate 1.

Genitalia of *Mylothris*.

(Valve and harpe).

Fig. 1. *smithi*. Madagascar.
2. *trimenia*. Kaffraria.
3. *croceus*. Kivu.
4. *similis similis*. Nyasaland.
5. *elodina*. Cameroons.
6. *ngaziya*. Comoro Is.
7. *phileris*. Madagascar.
8. *chloris chloris*. Gambia.
9. *chloris agathina*. Mombasa.
10. *rembina*. Cameroons.
11. *sulphurea basalis*. E. Congo.
12. *sulphurea* f. *sulphurea*. Cameroons.
13. *sulphurea* f. *solilucis*. Uganda.
14. *poppea rueppellii*. Abyssinia.
15. *poppea poppea*. Ashanti.
16. *nubila canescens*. Kivu.
17. *yulei yulei*. Nyasaland.
18. *rhodope rhodope*. Fernando Po.
19. *rhodope rhodope*. Angola.
20. *rhodope* f. *fernandina*. Fernando Po.
21. *rhodope* f. *schumanni*. Angola.
22. *rhodope* f *schumanni*. Cameroons.
23. *rhodope* f. *schumanni*. Cameroons.
24. *mortoni*. Abyssinia.
25. *sagala jacksoni*. Kenya.
26. *bernice rubricosta*. Kenya.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THE TWO STRAINS OF THE RICE WEEVIL, *CALANDRA ORYZAE* (L.) (COLEOPT., CURCULIONIDAE)

By O. W. Richards, M.A., D.Sc.

Manuscript received 27.vii.1943.

(Read 5.iv.44.)

With 6 Figures in the Text.

It is easy to discover that rice weevils vary greatly in size, but it is a natural first assumption that the kind of grain in which they are breeding is the main cause of variation. Thus very large specimens are often found associated with maize, while small ones are often found with Plate wheat.

Some preliminary experiments showed that while the kind of wheat had some effect on the size of the weevils, the principal cause of variation was the existence of two strains, one of which was about twice as heavy as the other.

Methods.

The water content (= W.C.) of wheat was estimated by grinding and heating a weighed quantity in a ventilated oven for 4½ hours at 110° C. The water content is expressed as a percentage of the wet weight.

Grain used for experiments was sterilised by heating for two to three hours in a closed Kilner jar at 110° C. and allowing the jar to cool slowly in the oven. The jar of grain is afterwards allowed a week in which to settle down.

Large cultures (50–200 g. of grain) of weevils were maintained in one-pound jam jars (depth 11 cm., diam. 6·5 cm.) with muslin tops. Small cultures, such as are derived from single females, were bred in 3 × 1-in. specimen tubes in 5 or 10 g. of grain. The cork had a hole five-eighths of an inch in diameter bored in it, and the hole was closed with fine-mesh brass gauze held in place by muslin; these are referred to as " tubes with bored corks."

Weevils were weighed either in groups or singly. The groups were weighed on an Oertling balance calibrated in milligrammes. Single weevils were at first weighed on a Sartorius balance calibrated in 0·2 mg. and read to 0·1 mg. Later, Dr. R. Dennell made a torsion balance after the plans of Dr. A. C. Fabergé; this balance was calibrated in 0·05 mg.

(a) *Establishing the existence of two strains.*

Experiment 1.

Small weevils were obtained from Plate wheat stored in the Port of London. Large weevils were taken from the insectary stock maintained at Slough. 132 weevils of each type were weighed and the mean weights of the two types were 1·30 and 2·42 mg. The wheat used for these weevils to breed on was (*a*) Plate wheat (W.C. 11·69%) of which 100 grains weighed 2·96 g., (*b*) English wheat (W.C. 14·04%) of which 100 grains weighed 3·72 g. 66 unsexed weevils were

added to 122 g. of English wheat and 98 g. of Plate wheat, giving about 50 grains per weevil. The set-up was as follows :—

Culture No.	Wheat	Weevils
1	Plate	Small
2	English	Small
3	Plate	Large
4	English	Large

The weevils were left on this wheat for 34 days at 25° C. 70% R.H. (in a constant temperature-humidity room). On the 41st day the cultures were examined for the new generation, which was found to have been emerging for some days.[1]

Thereafter the cultures were cleared twice a week (3- and 4-day intervals). This is not frequently enough to stop some breeding by the F_1 generation, so that after 11 clearings the experiment was stopped. On each occasion when the cultures were cleared the four groups of weevils were weighed and the mean weights calculated. The results are shown in Table I.

TABLE I.

Breeding the two strains of *C. oryzae* on Plate and English wheats.

Culture no. :	1		2		3		4	
Period	No. weevils emerged	Mean wt., mg.	No. weevils emerged	Mean wt., mg.	No. weevils emerged	Mean wt., mg.	No. weevils emerged	Mean wt., mg.
Up to 41st day .	114	0·92	376	1·00	23	1·91	259	2·15
41st to 48th day .	311	0·92	452	1·01	218	1·99	680	2·19
48th to 55th ,, .	296	0·93	422	1·04	393	1·94	538	2·09
55th to 62nd ,, .	285	0·94	394	1·01	311	1·90	400	2·03
62nd to 69th ,, .	195	0·92	269	0·99	188	1·78	208	1·90
69th to 76th ,, .	69	0·87	367 [2]	0·97	73	1·70	121	1·85
Totals and means	1270	0·92	2280	1·01	1206	1·90	2206	2·09

It is clear from Table I that though the type of grain has some influence on the weight of the weevils, the two strains are quite distinct. Over the prolonged emergence period the mean weights show a regular cycle of change, light–heavy–very light. This cycle is shown in most densely populated *Calandra* cultures, and the reasons for it are under investigation. Because of it, it is best to compare the weights of weevils obtained from the same part of the emergence curve.

A very large form of *C. oryzae* is sometimes found associated with maize. A number of such weevils was obtained from Plate maize in a Port of London warehouse. The mean weight per weevil of four lots of a hundred unsexed weevils was 2·98, 3·01, 3·08 and 3·08 mg. An experiment was set up to compare these weevils with the two strains already described.

[1] It was afterwards discovered that *C. oryzae* under these conditions has a minimum life-cycle of about 34 days.

[2] F_2 has begun to appear.

Experiment 2.

The weevils used were (1) Small, from culture 2 in Expt. 1. (2) Medium, from culture 4 in Expt. 1. (3) Large, from Plate maize described above. The three sorts of weevil were placed at 25° C. 70% R.H. in groups of 60 (unsexed) on 45 grammes of the following foods: (*a*) Plate wheat, W.C. 11·69%, 2·96 g. per 100 grains; (*b*) English wheat, W.C. 13·0%, 3·729 per 100 grains; (*c*) African white-toothed maize, W.C. 13·63%, 109 grains weighing 45 g. (approx.). The set-up of the experiment is shown in Table II. The parent weevils were removed on the 37th day and the cultures were examined for the new generation on the 40th day and thereafter at 3-day intervals until the 91st day. Culture 6 became contaminated with weevils of the small strain and the results obtained from this culture are omitted. A summary of the results obtained from the other cultures is shown in Table II.

TABLE II.

Set-up of Expt. 2 and its results.

Culture no.	Food	Weevils	Mean wt. of parents	No. of offspring	Mean wt. of offspring
1	Maize	Small	1·12	170	1·28
2	„	Medium	2·15	433	2·61
3	„	Large	2·73	241	2·77
4	Plate wheat	Small	1·02	889	0·87
5	„	Medium	2·15	707	1·74
6	„	Large	2·90	—	—
7	English wheat	Small	1·05	782	0·94
8	„	Medium	2·10	734	1·98
9	„	Large	2·82	417	2·02

It appears from Expt. 2 that there were only two major strains in the weevils tested, but that maize tends to produce large weevils. It is not in other respects a favourable diet, for Miss G. M. Herford discovered when working in this laboratory some years ago that the embryo of maize is toxic to first-stage *Calandra* larvae. This fact, which has since been verified, leads to a considerable wastage of the eggs which, especially in *C. oryzae*, are often laid near the embryo.

Experiments 1 and 2 established that there were two strains, and the differences between them were next studied.

(b) *Differences between the two strains.*

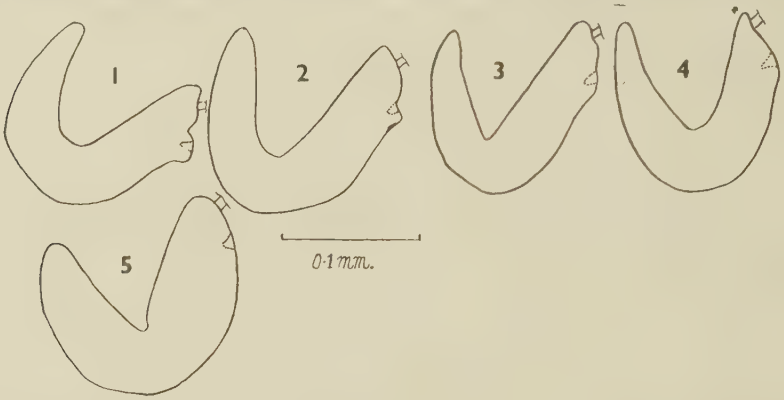
(1) *Morphological differences.*

There appear to be no discontinuous morphological differences but there are several characters in which the means of the two strains are widely different.

When both are mature, the large strain tends to be black while the small strain often remains a brown only somewhat darker than that of the younger weevils. The colour difference is even more marked on the dorsum of the abdomen (beneath the elytra), which is blackish in the large strain and very pale brown in the small one.

There is a marked difference in the average shape of the female spermatheca. At the point where the duct of the spermathecal gland enters the spermatheca

there is often a protuberance (figs. 1–5) which is much larger, on the average, in the small strain than in the large. In all the female weevils dissected the protuberance was classified into five types: absent, small, moderate, large, very



Figs. 1–5.—1, Female spermatheca, small strain, very large protuberance (surface striae omitted); 2, the same, large protuberance; 3, the same, moderate protuberance; 4, the same, small protuberance; 5, large strain, no protuberance.

large. Altogether, records were made of 1283 large females and 1117 small females and the five types of spermathecal protuberance had the following percentage distribution (Table III).

Table III.

Type of protuberance		Absent	Small	Moderate	Large	Very large	Total
Large weevils.	Nos.:	781	350	108	43	1	1283
	%:	60·9	27·3	8·4	3·4	0·1	—
Small weevils.	Nos.:	57	359	388	240	73	1117
	%:	5·1	32·1	34·7	21·5	6·5	—

The spermatheca of the large strain tends to have a greater diameter compared with its length but there is much overlapping in this respect.

The most obvious difference between the two strains is in the size, which was measured by weight. The weevils were normally weighed when 0–24 hours old; during the next week their weight may go up a little (*c.* 10%). Fig. 6 shows the distribution of weight amongst weevils of the two strains when bred upon English wheat. There is only a slight overlap. The sexes were studied separately but the sexual difference in weight is small and doubtfully significant, so the figures for the sexes have been combined. Included in the same figures are curves for the small weevils bred on maize and the large weevils bred on Plate wheat, foods which make the overlap very much greater (cf. data in Table XIII).

Table IV shows the measurements of the length of some weevils from the tip of the rostrum to the end of the abdomen. They enable an approximate conversion to be made from weight to length, the measurement normally used by systematists. In this table, the sexes are kept separate, since the rostrum

tends to be relatively longer in the female. The measurements were made with a screw-eyepiece micrometer.

TABLE IV.

Correlation of length and weight in *C. oryzae*.

No. of weevils	Mean wt., mg. ♂.	Mean length, mm.	No. of weevils	Mean wt., mg. ♀.	Mean length, mm.
		Large weevils.			
2	1·50	3·60	2	1·45	3·64
7	1·67	3·69	3	1·70	3·76
10	1·79	3·72	5	1·80	3·87
12	1·93	3·86	9	1·97	4·01
12	2·10	4·02	11	2·14	4·11
2	2·25	4·13	9	2·23	4·30
5	2·38	4·12	5	2·39	4·26
		Small weevils.			
3	0·67	2·87	13	0·95	3·18
10	0·96	3·08	8	1·16	3·37
15	1·09	3·19	10	1·29	3·45
9	1·22	3·34	3	1·48	3·74

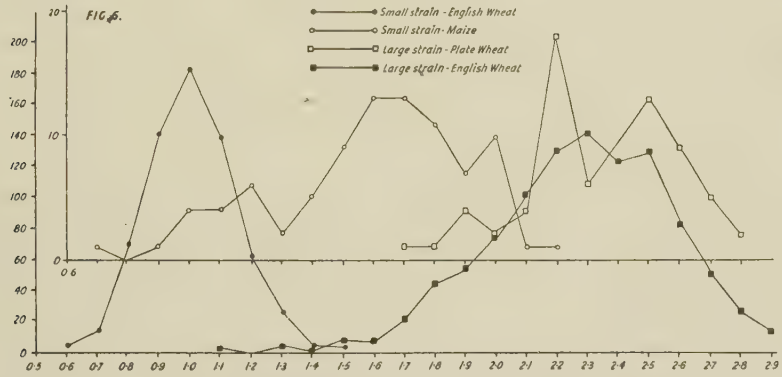


FIG. 6.—Distribution of weight of weevils of the small strain reared on English wheat and maize and of the large strain reared on Plate wheat and English wheat.

Mr. F. C. Grigg kindly made preparations of the male chromosomes of the two strains but found no certain difference between them. In both $2n = 22$.

In cultures of the small strain a brachypterous variety turns up which has never been seen in the large one. In this variety both the elytra and the wings are reduced to very small vestiges, usually of irregular shape. The brachypterous individuals die in a day or two and it has not been possible to obtain offspring from them. From the way in which the variety appeared in cultures derived from certain females it is suspected that it has a genetic basis. It has never appeared with a frequency higher than 5%.

(2) *Length of life-cycle at* 25° *C.* 70% *R.H.*

Experiment 3.

Five females of each strain were chosen as good layers. Each was placed in a tube with 10 grains of English wheat in equilibrium with 70% R.H. and for

7 successive days the female was moved into a new tube containing 10 similar grains. The females did not lay very well under these conditions; probably the daily transference disturbed them too much. The length of the life-cycle from oviposition to the appearance of the adult outside the host-grain is shown in Table V. It is clear that the cycle of the small strain is somewhat longer

TABLE V.

Length of life-cycle of *C. oryzae*.

Length of cycle (days)	Large strain			Small strain		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀
36	1	0	1	—	—	—
37	1	1	2	—	—	—
38	4	4	8	2	0	2
39	10	2	12	2	1	3
40	6	8	14	2	2	4
41	6	7	13	0	5	5
42	8	4	12	7	4	11
43	6	8	14	2	1	3
44	4	2	6	4	2	6
45	1	2	3	3	4	7
46	3	3	6	4	3	7
47	1	0	1	3	1	4
48	0	1	1	2	2	4
49	0	1	1	0	2	2
50	0	1	1	1	2	3
51	—	—	—	2	3	5
52	—	—	—	1	0	1
53	—	—	—	0	1	1
54	—	—	—	1	0	1
Totals :	51	44	95	36	33	69
Means :	41·2	42·0	41·6	44·6	45·1	44·8

than that of the large under these conditions. In both there is the wide spread in the emergence period characteristic of *Calandra* and perhaps partly due to the individual differences between grains.

(3) *Sexual Maturation.*

It was discovered that though isolated females of the large strain laid more eggs than small ones (p. 194) yet in mass cultures the small strain sometimes seemed to be more productive. There is no doubt that this great productivity is partly due to factors which have not been investigated, such as the survival of more than one larva in a single grain and reaction to accumulations of CO_2, yet the differences in the time taken by the two strains to reach sexual maturity is also important.

Experiment 4.

Weevils were removed daily from a number of standard cultures at 25° C. 70% R.H. If dissected immediately, they are 0–1 days old. For maturation the weevils were placed in groups of 4 ♂ 5 ♀ on 10 g. of English wheat in tubes with bored corks. The females were dissected and the number whose ovaries

contained at least one ripe egg, the number whose spermatheca contained at least a little sperm, and the number in which both sperm and ripe eggs were present, were all recorded. 100 females were dissected in each age group of each strain. Additional experiments showed that the rate of ripening of the eggs is quite or almost independent of fertilisation and is a measure of female maturity. At the same time, a mature male pairs quite or almost as readily with a very immature female as with a mature one; thus the number of spermathecae containing sperm is a measure of the maturity of the males. The results of the dissections, showing the difference in the rate of maturation of the two strains, are given in Table VI.

TABLE VI.

Dissection of sets of 100 females of the two strains of *C. oryzae*.

Age when dissected (days):	0–1	1–2	2–3	3–4	4–5	5–6
Large strain						
♀ with ripe eggs	0	0	4	21	50	75
♀ fertilised	0	9	44	69	88	96
♀ with ripe eggs, fertilised	0	0	2	15	47	73
Small strain						
♀ with ripe eggs	5	14	35	60	86	—
♀ fertilised	17	54	84	99	100	—
♀ with ripe eggs, fertilised	2	10	33	60	86	—

(4) *The oviposition-rates of the two strains.*

Experiment 5.

The oviposition-rates of the two strains were tested in the first place by isolating fertilised females (without males) in tubes with bored corks with a single grain for a number of successive two-day periods. This is a convenient method of measuring oviposition but it is known that the figures obtained are usually somewhat lower than those obtained by placing females in a large bulk of grain.

Table VII shows the mean oviposition-rate per female per day of fourteen females of the small strain and twelve females of the large at 25° C. 70% R.H. These had been reared on English wheat under the same conditions. They had been in cultures containing males for 14 days when they were used.

TABLE VII.

Average oviposition-rates (= eggs/♀/day) of isolated females, 14 of small strain, 12 of large, at 25° C. 70% R.H.

Two-day period no.:	1	2	3	4	5	6	7	8	Mean
Large strain	2·54	2·71	2·83	2·88	2·29	2·25	2·38	2·54	2·55
Small strain	1·71	2·07	1·90	1·71	1·65	1·50	1·58	1·62	1·71

In addition to this test of isolated females, two other experiments were carried out at different humidities at 25° C. with groups of 6 females.

Experiment 6.

The weevils used emerged on the 8th and 9th emergence days of cultures bred on English wheat at 25° C. 70% R.H. The weevils of the two strains emerging on the 8th day were matured with males on 10 g. English wheat at 25° C. 70% R.H. for 10 days; those emerging on the 9th day were similarly matured for 9 days. The mature females were isolated on single grains of wheat for 3 days and the number of eggs they laid was counted. 6 groups of 6 females of each strain were then made up, chosen so that in each strain each group had laid the same number of eggs in the three-day period. Three lots of English wheat were prepared, (1) R.H. 58%,[3] W.C. 13·15%, (2) R.H. 68%, W.C. 14·10%, (3) R.H. 76%, W.C. 15·96%. Two hundred grains of each lot of wheat were put into each of four tubes with bored corks and the tubes were placed in desiccators over potash solutions giving the appropriate relative humidities at 25° C. A group of 6 female weevils was added to each tube so that there were two groups of each strain in each desiccator. After 6 days, the weevils were removed and the grain was kept at 0° C. until it could be dissected.

Experiment 7.

A similar experiment was performed at relative humidities of 51% and 60%.[3] The general arrangement of the experiments was similar, two groups of 6 females of each strain being placed in each desiccator. The weevils used emerged on the 6th and 7th emergence days of cultures bred on English wheat at 25° C. 70% R.H. and were 21–22 days old when used.

The results of experiments 6 and 7 are shown in Table VIII.

TABLE VIII.

The oviposition of the strains of *C. oryzae* at different humidities at 25° C.

R.H. %	—	51	58	60	68	76
Total eggs laid by 12 ♀ in six days	Large	94	160	167	280	325
	Small	81	157	145	207	236
Eggs per ♀ per day	Large	1·31	2·22	2·32	3·89	4·51
	Small	1·13	2·18	2·01	2·88	3·28

The experiments show that while an increase in relative humidity increases the rate of oviposition in both strains, the effect is more marked in the large one.

(5) *Resistance of the Two Strains to Starvation.*

Experiment 8.

The weevils for this experiment were obtained from two cultures bred on English wheat at 25° C. 70% R.H. They were obtained during the same 6-day period of the emergence curve of the two cultures, which were cleared daily. Each day's set of weevils was put to mature for 14 days on about 10 g. of English wheat, W.C. *c.* 15%, at 25° C., groups of 10–28 maturing together in tubes with bored corks. On the fourteenth day, the weevils were made up into groups of about 10 (7–12), in tubes with bored corks, containing a piece of filter paper

[3] These relative humidities were determined by Miss N. Waloff with calibrated Edney hygrometers.

6 × 1·5 cm., folded longitudinally. The tubes were examined daily and the dead weevils removed and sexed. The various groups of ten weevils naturally were not found to be made up of equal numbers of males and females, but both sexes were present in every group, usually in approximately equal numbers. The results of this experiment are shown in Table IX.

TABLE IX.

The number of males and females of the two strains of *C. oryzae* surviving for 1–11 days at 25° C. 70% R.H.

Days	Small strain : nos. dying			Large strain : nos. dying		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀
1	0	0	0	0	2[4]	0
2	2	0	2	0	0	0
3	5	3	8	0	0	0
4	13	8	21	0	1	1
5	13	19	32	1	3	4
6	7	19	26	4	10	14
7	3	8	11	14	17	31
8	0	1	1	20	12	32
9	0	2	2	7	1	8
10	0	0	0	8	0	8
11	0	0	0	2	1	3
Mean :	4·63	5·53	5·15	8·07	6·98	7·58
No. of weevils :	43	60	103	56	45	101

The differences in days survival of the sexes of each strain are significant, and the difference between the two strains is also significant. It is interesting, therefore, to conclude that the large strain is not only more resistant than the small one, but that the relative resistance of the sexes is reversed.

(6) *Frass-ejection by the larvae of the two strains.*

It has been shown (1943, Richards and Oxley, *Proc. R. ent. Soc. Lond.* **18** : 22–24) that the larvae of *Calandra*, principally under the influence of CO_2, eject the frass which normally accumulates round them in the grain which they are hollowing out. With the rather dense cultures which are commonly used, the CO_2 produced by the larvae themselves often accumulates sufficiently in the bottom half of the culture jar to make the larvae eject large quantities of frass. It was soon noticed, however, that larvae of the small strain did so very much less than those of the large.

Experiment 9.

The following data were obtained from two stock cultures (small race 23 adults, large race 30 adults, each on 100 g. of English wheat, W.C. 14·06%) kept

[4] It was assumed that these two females were injured in handling and they have not been included in the totals or in calculating the means. It would alter the figure for the ♀ to 6·72 if they were.

at 25° C. 70% R.H. Each culture was sieved on the 35th day, when the new generation was just beginning to emerge (see Table X).

TABLE X.

Quantity of the frass sieved off from stock cultures of the two strains.

Strain	Mg. of frass	No. of weevils later emerging	Mg. of frass per 100 weevils
Large . . .	446	618	72·0
Small . . .	13	560	2·4

This suggests that the larvae of the two strains react quite differently to CO_2, even allowing for the fact that the larger strain produces more CO_2. This supposition was tested in the following way.

Experiment 10.

20 g. of English wheat, W.C. 14·31%, was exposed to 50 weevils of the small strain for 2 days at 25° C. R.H. 70%. 110 g. of the same wheat was similarly exposed to 250 weevils of the large strain. The 20 g. were then sieved and put in a small circular glass vessel, 4·2 cm. diam., 2·0 cm. high, and covered with muslin. The vessel was stood in the bottom of a 1-lb. jam jar (diam. 6·5 cm.) and the 110 g. were sieved and poured over it, covering the muslin of the small vessel to a depth of 3·5 cm. and filling the jar to a depth of 5·5 cm. Thus grain infected by the small strain was surrounded by grain infected by the large strain and being near the bottom of the culture the small strain should have been exposed to nearly the highest CO_2 concentration present. On the 32nd day the two lots of grain were sieved separately and the frass weighed. The grain was then kept and the weevils which emerged were counted. The following results were obtained (Table XI).

TABLE XI.

Quantity of frass produced by weevils of the two strains under comparable conditions.

Strain	Mg. of frass	No. of weevils produced	Mg. of frass per 100 weevils
Large . . .	64	54	118·5
Small . . .	4	118	3·4

From this experiment it is clear that as far as ejection of frass goes the two strains react quite differently to accumulated CO_2.

(c) *Crosses between the two strains.*

Experiment 11.

Weevils of each strain derived from Expt. 2 were bred on English wheat at 25° C. 70% R.H. Some of their offspring were sexed [5] and isolated when 0–24

[5] *C. oryzae* male has the dorsal surface of the rostrum striate and punctured, whereas the female has it shining and almost unpunctured.

hours old in 3 × 1-in. glass tubes with one grain of wheat. In the case of females, the grain was left for five days and then examined for eggs. The two or three females (all of the small strain) which produced eggs in the 5-day period were rejected and the remainder were regarded as unfertilised.

The weevils were then weighed individually. The small weevils weighed : females 0·8–1·4, mean 1·066 mg., males 0·8–1·3, mean 1·045 mg. The large weevils weighed : females 1·5–2·7, mean 2·232 mg., males 1·7–3·0, mean 2·263 mg. They were paired up in tubes with bored corks. Each tube contained 10 g. (depth 2·8 cm.) of English wheat, W.C. 14·20%, and was maintained at 25° C. 70% R.H. The parent weevils were left on for 20 days and the F_1 were removed at 3-day intervals from the 36th day onwards. The results of the crosses are shown in Table XII.

TABLE XII.

Crosses between large and small strains of *C. oryzae*.

Type of cross	No. of pairs	No. of pairs producing offspring	Total no. of offspring			Range in weight of offspring, mg.[6]	Mean wt. of offspring, mg.	
			♂	♀	♂ + ♀			
Large × large	17	17	381	385	766	1·6–3·0	2·365	
Large ♂ × small ♀	24	4	5	4	9	1·2–2·0	1·700	1·625
Small ♂ × large ♀	20	2	2	2	4	1·1–1·7	1·475	
Small × small	20	19	506	521	1027	0·7–1·5	1·042	

It is clear from Table XII that the two strains can only cross with considerable difficulty. The hybrid offspring were made up into pairs which were given 10 g. of wheat for 20 days but no offspring resulted, though similar pairings amongst the F_1 of the large and small strains produced large numbers of offspring.

It was thought that the failure of the two strains to cross might be due mainly to their difference in size. To test this, small examples of the large strain were produced by rearing them on Plate wheat and large examples of the small strain were reared from maize.

Experiment 12.

(*a*) 50 weevils of the small strain (F_2 from expt. 11) were put on 100 g. of American maize, W.C. 13·80%. (*b*) 50 weevils of the large strain were put on 100 g. of Plate wheat, W.C. 13·09% ; these were incubated at 25° C. 70% R.H. ; 88 weevils from (*a*) and 72 from (*b*) were weighed individually. The following distribution of weights was found amongst these weevils—Table XIII.

These weevils, after being shown to be virgin in the way previously described, were paired up in the four possible ways with the arrangement that in hybrid crosses the male and female had as nearly as possible equal weights, whereas in the straight crosses the male and female had as big a difference in weight as possible. They were given 5 g. of English wheat, W.C. 14·3% for 20 days at 25° C.

The results of these crosses are not essentially different from those recorded in Table XII and it seems that size is not an important factor in preventing crossing.

[6] Only a sample of the offspring was weighed.

TABLE XIII.

Weights of large and small *C. oryzae* bred on Plate wheat and maize respectively.

Wt. in mg.	Small weevils			Large weevils		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀
0·7	1	0	1	—	—	—
0·8	0	0	0	—	—	—
0·9	0	1	1	—	—	—
1·0	3	1	4	—	—	—
1·1	2	2	4	—	—	—
1·2	5	1	6	—	—	—
1·3	1	1	2	—	—	—
1·4	4	1	5	—	—	—
1·5	6	3	9	—	—	—
1·6	9	4	13	—	—	—
1·7	5	8	13	0	1	1
1·8	6	5	11	1	0	1
1·9	4	3	7	1	3	4
2·0	2	8	10	0	2	2
2·1	1	0	1	2	2	4
2·2	0	1	1	10	6	16
2·3	—	—	—	2	4	6
2·4	—	—	—	4	5	9
2·5	—	—	—	5	8	13
2·6	—	—	—	3	6	9
2·7	—	—	—	4	1	5
2·8	—	—	—	1	1	2
Total nos.:	49	39	88	33	39	72
Mean roots:	1·575	1·677	1·618	2·336	2·336	2·349

TABLE XIV.

Results of crossing weevils of similar size belonging to large and small strains.

Type of cross	No. of pairs	Difference in wt. between members of pair		No. of pairs giving offspring	Total no. of offspring			Mean wt. of offspring, mg.
		Range, mg.	Mean, mg.		♂	♀	♂ + ♀	
Large × large	6	0·3–0·6	0·48	5	80	95	175	2·500
Large ♂ × small ♀	12	0·0–0·5	0·28	1	1	0	1	1·50
Small ♂ × large ♀	12	0·0–0·4	0·15	3	2	11	13	1·79
Small × small	6	0·2–0·9	0·53	6	110	112	232	1·081

The small and large females (except two of each which were dead) from the hybrid crosses recorded in Table XIV were afterwards separated from the males and paired up with a male of their own strain. The males were obtained from various pairs recorded in Table XIV. As a result of this second pairing 9 of the 10 females of the small strain produced offspring, 258 ♂♂, 239 ♀♀ in 20 days. On the other hand, only 2 of the 10 females of the large strain produced offspring 6 ♂♂, 6 ♀♀. No reason can be suggested why these females of the large strain

should not have laid normally, unless the previous exposure to a small male had in some way damaged them. A later experiment to test this hypothesis did not confirm this observation.

Of the hybrid crosses recorded in Table XIV, 2 lots of grain from each type of hydrid cross were dissected to see whether any eggs had been laid, but had failed to develop. The results of this examination are shown in Table XV. It

TABLE XV.

Dissection of grain exposed for 20 days to a female *Calandra* paired with a male of the other strain.

Type of cross	No. of adults produced	Dead early stages found by dissection of grain
Small ♀ × large ♂ . . .	1	5 eggs
,, ,, . . .	0	1 egg
Large ♀ × small ♂ . . .	0	3 eggs
,, ,, . . .	7	22 eggs, 1 first-stage larva

is clear, as might have beeen expected, that the hybrid eggs are not very viable and probably many more eggs are laid than offspring are produced. There is evidence from other experiments that female *Calandra* lay very few eggs when unfertilised.

The 11 hybrid females which were produced (Table XIV) were isolated in tubes with a single grain which was changed every two days. Two females died on the first day, but of the nine others, four laid eggs, three of them in some numbers (1–1·5 a day), but none hatched (grain dissected after ten days' incubation). The five females which did not lay for four two-day periods were then given males of the original strains, three large males and two small males. The three which were given large males immediately started laying 2–2·5 eggs a day but none hatched. The two given small males laid no eggs for three two-day periods; they were then given large males and one of them laid a few eggs which did not hatch. Eventually, all the females which had laid eggs were dissected by Mrs. R. F. Ewer. The spermatheca in each female contained sperm. The other reproductive organs appeared to be normal but there was usually a curious green spot at the base of egg-tubes where there is no spot in normal females. To sum up: most of the hybrid females are capable of oviposition; about half of them if fertilised by hybrid males and all of them if fertilised by males of the large strain. The eggs were incubated for 10 days (normal egg-period at 25° C. is five days) but none hatched and the eggs were evidently shrivelled and dead.

SUMMARY.

1. Two strains occur in *Calandra oryzae* which differ principally in size (weight). Genetic factors affect weight considerably more than does the type of grain used.

2. The two strains only cross with great difficulty and the hybrids appear to produce no viable offspring. The strains are nevertheless not regarded as species since there is no non-overlapping morphological difference or combination of differences between them.

3. The strains differ in all the physiological characters which have been investigated, viz. length of life-cycle at 25° C., rate of sexual maturation, oviposition-rate, resistance to starvation and ejection of frass by larva.

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STUDIES ON THE CHEMISTRY OF PIGMENTS IN THE LEPIDOPTERA, WITH REFERENCE TO THEIR BEARING ON SYSTEMATICS. 4. THE CLASSIFICATION OF THE PAPILIONIDAE

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1. Introduction.

The family Papilionidae comprises the Swallow-tail Butterflies and their allies, amounting in all to about 508 known species. It includes the largest Rhopalocera in the world and provides many notable instances of mimicry and polymorphism, while it extends to all the chief faunistic regions. It has indeed long attracted the special attention of entomologists and its classification has often been discussed. In the present paper I propose to reconsider the systematics and phylogeny of the family, using as many criteria as appear to be available. These include not only the structural characters which have been employed by previous authors, but the data on the chemistry

of its pigments revealed by my own investigations (Ford, 1941, 1944). In these works I have shown that anthoxanthins are present in certain of the species and absent from others, also that two types of red pigment occur in the family. The distribution of these substances is closely related to the classification which had been elaborated on purely structural grounds. Their nature, and the methods used in detecting them, have already been discussed (Ford, *loc. cit.*). It is only necessary therefore to summarise this subject very briefly here.

The anthoxanthins are a group of plant pigments ranging in colour from ivory to deep yellow. Animals cannot manufacture them but obtain them from their food. However, they appear to be so widespread that they are available to any species that is capable of using them. Certain members of the PAPILIONIDAE employ them, but the white and yellow pigments of this family are generally of an entirely different nature, being built up by the insects themselves; and this is more usual throughout the Lepidoptera.

I have for convenience labelled the two red pigments found in the PAPILIONIDAE as types A and B. For an account of their characteristics, see Ford, 1942, 1944. Pigment A is widely distributed in the Lepidoptera, while B has so far been found only in the PAPILIONIDAE. These two pigments may readily be distinguished by the following means. Type A is quickly converted from red to yellow by strong mineral acids (*e.g.*, HCl gas). It is reconverted to red by alkalis (*e.g.*, ammonia) with great rapidity. It is soluble in concentrated nitric acid but does not give a murexide reaction. Type B, on the other hand, is almost unaffected by acids, except that it may be changed by them to a slightly duller or more bluish tint. It is insoluble in concentrated nitric acid. I hope to discuss the chemistry of these and other red pigments of the Lepidoptera in a subsequent paper.

I wish to record my most grateful thanks to those who have given me their most valuable help. Professor G. D. H. Carpenter and Mr. N. D. Riley have respectively placed at my disposal the vast resources of the Hope Department of Entomology at Oxford and of the Department of Entomology of the British Museum (N.H.) at South Kensington and Tring. Moreover, they have been so good as to give me their opinion on this work. It is a pleasure to acknowledge the assistance which I have also received from Dr. A. S. Corbet, Mr. A. G. Gabriel, Professor E. S. Goodrich, Dr. K. Jordan, and Mr. G. Talbot. All these authorities have been to very considerable trouble in reading this paper in detail. I have been greatly assisted by the views which they have expressed to me.

2. The Status of certain Genera.

(a) *Battus* Scopoli, 1777.

Rothschild and Jordan (1906) and Jordan (1907–8) have stressed that the American "Aristolochia Swallowtails" are divisible into two sharply contrasted sections. The great majority of them scarcely differ from those of the Old World (see p. 204–5) and belong to the same genus, *Atrophaneura* Reakirt (= *Polydorus* Swainson, praeocc.). The second section comprises only the 14 species included by Jordan in his "Polydamas Group." These are so unlike all other *Atrophaneura* species that their separation as a distinct genus would seem desirable on structural grounds. When the nature of their red pigment is also taken into account (Ford, 1944), the matter can no longer remain in doubt.

The generic name *Battus* Scopoli (1777, *Intr. Hist. Nat.* : 433) is available for the species of the former " Polydamas Group." The type is *polydamas* L., this having been selected by Lindsey (1925, *Ann. ent. Soc. Amer.* **18** : 80) from among the 81 species which Scopoli included in the genus (see Hemming, 1934). *Battus* is not even mentioned by Bryk (1923–30), who lists *Ithobalus* Hübner, 1818, which, as Hemming shows, falls as a synonym of it.

The species of *Battus* differ from *Atrophaneura* in the following characters. The antennae are without deep sensory grooves on the ventral side, and their terminal segment is very short. The cell of the hind-wing is rounded at its apex, and its lower angle is at least as large as its upper. The lower cross-vein of the hind-wing leans distally anteriorly. The tibiae are not thickened. The scent-organ on the hind-wing of the male is never woolly, and there is a naked streak along the margin of the enclosing fold. The red colours are invariably due to pigment B, that characteristic of *Papilio*; while in *Atrophaneura* they are invariably due to pigment A, that characteristic of *Graphium* (Ford, 1940, 1944). Red spots or bands are not found in the centre of the hind-wing on the upper side. The lateral tubercle on the prothoracic segment of the larva is greatly prolonged. The dorsal humps of the pupa are narrow.

Moreover, the habits of the two genera are very different. The species of *Battus* fly in open country, seldom being found in woods, while those of *Atrophaneura* are essentially forest insects. *Battus philenor* L. and *B. polydamas* L. are the only North American members of the Troidini.

It will be apparent that *Battus* differs from *Atrophaneura* in structure, chemistry, and habits, so that its separation as a genus seems a necessity. It may be added that one distinguishing character of *Battus* quoted by Jordan (1907–8) for his Polydamas Group, can hardly be substantiated. He says that the body is never spotted with bright red. Red spots on the body are unusual in *Battus*, and in this respect the genus differs from *Atrophaneura*, but they occur in *B. polydamas*. They are not so " bright " as is general in *Atrophaneura*, owing to the difference in red pigment.

Battus may be divided into two Groups. A " Philenor Group " contains three species which normally possess tails. These are *B. philenor* L., *B. devilliers* Godt., and *B. zetes* Westw. (though a small form of *B. philenor*, *orsua* G. & S. from the Tres Marias Islands, is tailless, as are some Mexican specimens). A " Lycidas Group " includes the remaining eleven species listed by Jordan (1907–8) in his " Polydamas Group." All these are tailless.

(b) *Troides* Hb., 1819.

The Priamus Group of " Aristolochia Swallowtails," or " Ornithoptera," has by certain authors been separated from the majority of the genus *Atrophaneura* chiefly, it would seem, on account of the great size of the species it contains. Indeed it includes the largest known Rhopalocera. Jordan (1908–9) does not adopt this procedure. He says that the term Ornithoptera " is scientifically untenable, because not definable morphologically. Apart from the size the characterisation of the group is founded upon purely external peculiarities of form and colouring, some of which have broken down in the light of more recent discoveries." Rothschild (1895) does separate *Troides* but remarks : " This I have done more for the sake of the general entomologist than from a justifiable scientific reason." However, Bryk (1923–30), Talbot (1939), and the authorities at the British Museum, all regard these insects as constituting a distinct genus, for which the name *Troides* Hb., 1819 (= *Ornithoptera* Bdv., 1832) should be employed. The reasons for doing so

are summarised by Talbot (*loc. cit.*). Some of them depend merely upon the large size of the species; apart from these, the characteristics of *Troides* which he cites are: The scent brushes on the hind-wings of the males are particularly well developed (there is a brush of hairs on the underside near the inner margin). Vein 11 on the fore-wings arises from a point opposite vein 2 (instead of opposite vein 3 as in *Atrophaneura*). The head is black and the collar red [but there are several exceptions to the latter character]. In the male the claspers are large, instead of being of a normal size or else reduced as they are in *Atrophaneura*. The pupa, unlike that of the other groups of the family, is sustained by separate threads attached to a tubercle on each side, and not by a loop round the middle.

It must be admitted that these are rather slender grounds for the recognition of a genus, and Talbot rightly stresses that, morphologically, *Troides* and *Atrophaneura* are very close to one another. Yet Cockayne (1924) has provided a further distinguishing character which Talbot does not mention. He pointed out that yellow colours are very common in *Troides* and that they are due, in both sexes, to a pigment which gives a greenish-yellow fluorescence in ultra-violet light. Moreover, it is soluble in strong acetic acid and in alcohol, the solutions also being fluorescent. He has demonstrated that this pigment is strictly confined to *Troides*: it is never found in *Atrophaneura*. Taking into account this additional criterion of Cockayne, *Troides* seems worth treating as a separate genus.

I have detected no other chemical differences between the two genera. The species of *Troides* resemble all Old World (but not all American) *Atrophaneura* in possessing no anthoxanthins, while the red pigments of both *Troides* and *Atrophaneura* are invariably of type A (though they are restricted to the body in *Troides*). Certainly the two genera are very closely allied.

Zeuner (1943) has recently published a detailed analysis of the genus *Troides* in which he discusses the relationships of the species contained in it and relates their distribution to the geological history of the region which they inhabit. This is a very valuable piece of work, especially as so little attention has been paid to the bearing of palaeontology on the systematics of the Lepidoptera. However, it has no close connection with the present study, which is concerned not with the arrangement of species within the various genera but with the affinities of the genera, tribes, and sub-classes of the Papilionidae. Zeuner subdivides *Troides* into four main groups, which he wisely refrains from erecting into separate genera, though he is inclined to think that three of them might be regarded as generically distinct. I should not myself agree with such a view. A minute study of any assemblage of species naturally throws particular emphasis upon its sub-divisions and tends to magnify their importance. As I have already indicated, it appears to me that *Troides* as a whole is only just worth separating as a genus distinct from *Atrophaneura*. Though certain of the species placed in it fall into natural associations, they may appropriately be treated as groups within a single genus but not as separate genera; for they would then represent an entirely different classificatory level from that used elsewhere in the Papilionidae.

(c) *Atrophaneura* Reakirt, 1865.[1]

The American species of this genus are superficially somewhat distinct from those of the Old World. They differ also in a minor structural peculiarity,

[1] *Atrophaneura* Reakirt 1865, is the oldest valid name for the genus long known as *Polydorus* Swainson 1833, preoccupied by a genus of the Annelida (see Corbet, 1943).

for the sinus of the fifth tarsal segment, in which the claws are inserted, is smaller in the American than in the Old World forms. My own investigations also indicate some slight divergence between them, for I find that anthoxanthins occur, though in small quantities only, in a number of the American species (13 out of 29 tested), but never in those of the Old World (31 tested). However, these characters certainly do not warrant the separation of the American section as a distinct genus. Yet should further research elicit any other constant distinctions, the matter would at least be worth reconsidering.

I have obtained no chemical evidence that *Atrophaneura antenor* Drury is in any way exceptional. Like all other Old World *Atrophaneura*, it is without anthoxanthins and its red pigment is of type A. Yet this species provides a remarkable instance of discontinuous distribution. It is confined to Madagascar, while the genus does not exist anywhere else in the Ethiopian Region; nor do any of the other known species inhabiting the Old World occur west of India, so far as can be ascertained. *A. antenor* therefore supplies further evidence for the Oriental affinities of a section of the Madagascan fauna, which are notable in other groups of animals. In spite of its isolation, it has only one minor specialisation, and to this attention does not seem previously to have been directed. I refer to the shape of the antennae, in which the club is straight instead of curved in the manner characteristic of the family.

(d) *Cressida* Swainson, 1833, and *Euryades* Felder, 1864.

I am convinced that *Cressida* (= *Eurycus* Bdv., 1836) from the Australian Region and *Euryades* from South America are closely related genera, and that they should be combined within the sub-family Papilioninae as a tribe which may be called the Cressidini. Many of their joint characters are primitive and, since these will be discussed on pp. 213–14 in relation to the phylogeny of the family, they will only be referred to briefly here. In these two genera a distinct trace of vein 1*b* of the hind-wings is preserved. Indeed their venation is similar, except for the condition of the pre-costal vein on the hind-wings. The red pigments are of type A. The females possess a horny pouch after copulation. This circumstance, and their thinly scaled wings, have led some authors to the erroneous conclusion that these two genera are related to the Parnassiinae, from which they differ profoundly in their venation and their early stages. The horny pouch is in fact a primitive character of the Papilionidae (see p. 211). The larvae are furnished with fleshy tubercules and feed on Aristolochia, and the pupae are attached to plants by a cremaster and silken girth.

Attention must also be drawn to the curious and very similar sexual dimorphism of these genera. The males are white or yellowish insects, strikingly marked with black or chocolate brown and spotted with red. The females are semi-diaphanous. Their markings are indistinct, being of a lightish brown shade on a yellowish-brown ground colour, and the red spots are pale. Indeed even when fresh, they give the superficial appearance of worn insects.

It may be noticed here that in *Euryades*, which is the more primitive (p. 214), the club of the antennae is curved, while in *Cressida* it is straight. But such a distinction occurs repeatedly between insects which must be placed within the same tribe (*e.g.*, *Archon* and *Parnassius*, or *Lühdorfia* and the other genera of the Zerynthiinae). In *Euryades* the male claspers are preserved while in *Cressida* they are aborted, a contrast to be found within the single genus *Atrophaneura*.

(e) (*Chilasa* Moore, 1881).

Talbot (1939) has separated from *Papilio* a small section of Oriental species as a distinct genus *Chilasa*. He states that it comprises four Groups: these are the Agestor, Clytia, Laglaizei, and Anactus Groups (9 species in all). Jordan (1908–9) had combined these four groups with a fifth, the Castor Group, to form the first of his two sections of Fluted Swallowtails (*Papilio*). However, Talbot does not include the Castor Group in *Chilasa* as the larvae and pupae are fairly typical of *Papilio*, and it is on the peculiarities of these two stages that *Chilasa* is chiefly founded.

Chilasa is said to differ from *Papilio* in the following characters: always mimetic, resembling other than species of *Atrophaneura* [it seems doubtful if this is true of *anactus* MacLeay, though it has been suggested that it mimics *Acraea andromacha* F. Even so, mimicry of this type is hardly diagnostic, since some forms of *Papilio canopus* Westw. seem to mimic Danaidae, and the Castor Group certainly does so]. The abdomen is marked with rows of white spots, and there is a white dot or spot at the base of the hind-wing [but these characters are true of the Castor Group of *Papilio*]. The larva is without oblique bands [but so is that of *Papilio machaon* L.], and it has two or three rows of spines. The pupa is stick-like, the head without horns [yet this is not true of *anactus*].

These characters are distinctly superficial, and most of them are subject to exceptions. Nor do chemical considerations assist the separation in any way. Only one species, *anactus*, possesses red pigment, and this is of type B as in *Papilio*. All but *toboroi* Ribbe can be tested for anthoxanthins and these are invariably absent, again as in *Papilio*. The characters on which the genus has really been established are those of the larvae and pupae. The presence of spines in the larvae cannot be pressed very far, for these are found also in the young larvae of *Papilio*, though there they do not persist. The curious stick-like pupae, lacking the two horns at the head that are a notable feature in *Papilio*, are certainly very striking. But this seems to be a cryptic adaptation; so that it may be of little more classificatory value than the peculiar colour-patterns of the imagines, which are the result of mimicry, and to these no taxonomic significance can be attached. Mimetic insects naturally differ considerably from their allies in this respect.

The larva of *anactus* bears short spines, but its pupa is not of the specialised stick-like form, being much more like that of a normal *Papilio* (Waterhouse, 1932). Possibly therefore the peculiar stick-like pupa is merely a special adaptation of the Agestor and Clytia Groups. Nor does it seem certain that these are closely related to *anactus* and to the Laglaizei Group. The latter comprises two [2] mimics of the Uraniidae (*laglaizei* Depuis and *toboroi* Ribbe). The larva of *laglaizei* is known. It is indeed of the spotted type and bears short spines as in the other "Chilasa" species, but I cannot find that the pupa has ever been described. These Laglaizei species are superficially so dissimilar from the Agestor and Clytia Groups that it seems necessary to await information on their pupae before arriving at any definite conclusion on their systematic position. Indeed I do not feel at all satisfied that the Laglaizei Group has its affinities here.

There can be no doubt that *Chilasa* is much less distinct from *Papilio* than is *Atrophaneura* or *Graphium*. Its true status cannot certainly be deter-

[2] A third species, *moerneri* Auriv., from New Britain, has been described, but it is known only from one or two specimens.

mined until further data have been obtained. However, for the present it seems to me more satisfactory to regard the "*Chilasa*" species as a specialised section within *Papilio* than as a separate genus. It may well be found that the assemblage is not a homogeneous one, and that the four groups which it contains cannot all be kept together.

(f) (*Agehana* Matsumura, 1936).

A single species, the rare *elwesi* Leech from south-eastern China, has been separated from *Papilio* by Matsumura and placed in a distinct genus *Agehana*, see Hemming (1939). This depends solely upon the circumstance, usually said to be unique in the family, that the tail is provided with two veins. These are 3 and 4, the latter being that which normally traverses it. For in this species the tail is extraordinarily broad, so that it requires extra support. There are numerous instances in which it is spatulate (e.g., *Papilio nephelus* Bdv.) but, having a narrow attachment, only a single vein enters it. In *Papilio elwesi*, however, the base is extended sufficiently far along the wing to include vein 3.

Dr. K. Jordan has pointed out to me that an almost perfect transition between the normal tail of *Papilio* and that of *P. elwesi* is provided by *P. rhetenor* Westw. The male of that species is tailless, but the tail of the female is very broad and its basal portion is supported by vein 3 as well as vein 4. Vein 3 is here shorter than 4, so that the tail has a short posterior lobe, while there is a red marginal spot between the two veins. Otherwise the condition is the same as in *P. elwesi*.

Naturally, wherever a tail is formed, any vein reaching its base is produced down it, as in the three tails of *Bhutanitis*. I have heard it said that the additional vein in the tail of *Papilio elwesi* is not a simple continuation of 3 but a distinct branch of it. This is not correct. The two veins in the tail of this insect are mere prolongations of 3 and 4.

I do not see that the possession of a tail broad enough for two veins to enter it is more remarkable than would be the occurrence of two tails, each supported by a vein, in a species otherwise allied to single-tailed forms (e.g., *Papilio*), were such to be discovered. If this be granted and *Agehana* upheld, the two sexes of *Teinopalpus imperialis* Hope [3] should be placed in separate genera!

No other characters are known to distinguish the genus *Agehana*, and chemistry supplies none. The only species assigned to it does not possess anthoxanthins, and its red pigment is of type B, as in *Papilio*. Now to found a genus upon a single character is a dangerous procedure; a caution which applies with quite special force when it is mono-specific. This is true even when the distinguishing feature involved is a much more fundamental one than wing-venation, which is subject to quite wide individual variation in the Papilionidae. In other Orders of insects which have received more thorough genetic analysis than have the Lepidoptera, instances are well known in which profound changes in venation, with or without alterations in wing-shape, are controlled by single genetic factors giving simple segregation (e.g., *Drosophila melanogaster*). But this is sometimes true also of characters normally regarded as of greater than generic significance. *Datura stramonium* is a plant belonging

[3] This species always possesses a tail in the position normal for the Papilioninae, at vein 4. But in the female, though not in the male, a second long tail is developed at vein 6.

to the family Solanaceae, which has seed capsules with two carpels. Yet in this species a single genetic factor is responsible for the production of capsules with three carpels, a condition known in other families (*e.g.*, the Polemoniaceae) but not in the Solanaceae (Blakeslee, Morrison, and Avery, 1927). Characters of a most surprising kind may even arise by a single mutation within a species, so that to establish a mono-specific genus upon a single character is a most unjustifiable procedure. Although genetic factors have multiple effects, the validity of a supposed generic difference becomes greatly strengthened as the number of characters involved in it increases. It is by the accumulation of distinct characters, not upon a single noteworthy difference, that genera may most safely be founded.

The separation of *Agehana* from *Papilio* does not even involve an alteration in venation. It should not be adopted, for the only difference between them follows as a necessary consequence of the *shape* of the tail. Dr. A. S. Corbet, Mr. A. G. Gabriel, and Mr. G. Talbot have kindly allowed me to say that they agree with my view, that *elwesi* Leech should not be separated from *Papilio*.

3. Classification.

A new classification of the Papilionidae, embodying the results of investigations on chemistry as well as on structure, is much needed. Apart from the omission of chemical criteria, each of the systems of classification so far proposed for the family is subject to certain drawbacks, or else is incomplete. The earliest of them that need be noticed here is that of the *Macrolepidoptera of the World*, for this supersedes all previous accounts. It has the special advantage that the larger part (the Palaearctic and African Sections alone excepted) is the work of Dr. K. Jordan, F.R.S., whose unique knowledge and sound judgment deservedly invest it with exceptional authority. The other authors, Dr. A. Seitz and Dr. C. Aurivillius, are also of the first rank. On the other hand, this treatise is at a disadvantage in certain respects. The most recent sections are more than thirty years old, and much information has accumulated since then. Since the different geographical regions are discussed separately, no general view of the classification of the family is obtained. In fact it is impossible to arrive at any concept of the result which would have been reached had the three authors combined to produce a single classification of the entire family. Finally, considerations other than affinity must at times have guided the arrangement. For instance, Jordan (1908–9) points out with his usual insight that *Lamproptera* (*Leptocircus*) must be derived from *Graphium* (*Cosmodesmus*), a conclusion for which long afterwards I was able to provide independent evidence (Ford, 1938). Yet between *Lamproptera* and *Graphium* he interposes *Cressida* (*Eurycus*), a genus of Aristolochia butterflies in which the female develops a " pouch." It can hardly be thought that this sequence is a natural one.

The most recent classification of the whole family is that of Bryk (1923–30), but this is unsatisfactory in many respects. It is extremely unequal in its systematic treatment. *Parnassius* is (quite unjustly) subdivided into three genera while *Atrophaneura*, *Papilio*, and *Graphium* are still united in one immense genus. Furthermore, the arrangement cannot be held to reflect phylogeny. *Lamproptera* is separated from *Papilio* so-called (containing its true relatives, the *Graphium* species) by *Cressida*, *Euryades*, and *Troides*; while *Teinopalpus* is placed between *Baronia* and *Zerynthia*, a procedure which it would be hard indeed to justify. Though this volume of the *Lepidopterorum*

Catalogus is very useful as a register of literature, the classification adopted in it requires much revision.

By far the most valuable works on the classification of the PAPILIONIDAE since the *Macrolepidoptera of the World* are those of Evans (1932) and of Talbot (1939). Unfortunately, they are limited to India, and but a small proportion of the species and only 9 out of the 17 genera [4] occur there. I am in close agreement with the arrangement adopted in these admirable books, as far as it goes. Had the classifications of Evans and of Talbot been extended to cover the whole family, my present task would have been greatly simplified.

(*a*) The Primitive Characters of the PAPILIONIDAE.

A comparative study of the PAPILIONIDAE allows us to determine with high probability some of its primitive characters. These must be enumerated and briefly discussed. I do not provide a list of the general characteristics of the family as a whole or of its various groups, for this can be obtained from the standard text-books.

(1) *Wing venation.*

The ancestral PAPILIONIDAE were a group possessing all thirteen veins in the fore-wings (1*a*, 1*b*, 2–12). The loss of vein 9 is a specialisation which has occurred only in the higher PARNASSIINAE (*Parnassius* and *Hypermnestra*) and, probably independently, in *Baronia*. All these veins were free. The fusion of 11 with 12 is undoubtedly a specialisation which has occurred, independently, in two genera only, *Baronia* and *Graphium*. In the latter, it is found, with rare exceptions, in all the Old World species, but in those of America 11 and 12 are rather more often free than fused.

There was a well-developed median spur. For this is present in all the existing PAPILIONINAE, including the primitive Cressidini; the only exception being *Teinopalpus*, in which it is vestigial. Though absent as a perfect structure from the other three subfamilies, its presence as a vestige in two genera of the ZERYNTHIINAE (*Sericinus* and *Bhutanitis*) strongly suggests that it is an essential attribute of the family.

Nearly all authors maintain that vein 1*b* is universally absent from the hind-wings of the PAPILIONIDAE and that this is a fundamental feature in which that family differs from the PIERIDAE, and indeed from all other Rhopalocera. This is a most extraordinary statement, for it is quite incorrect. As lately stressed by Zeuner (1943), there are numbers of PAPILIONIDAE in which both of the anales, veins 1*a* and 1*b* of the hind-wings, are present and well-developed. However, 1*b* is always much the thinner of the two, and in the majority of the species it does actually disappear, though in these its position is often marked by a distinct furrow on the upper side. As Zeuner (*loc. cit.*) says, " The dividing line between PAPILIONIDAE and PIERIDAE must not be drawn by means of the number of anal veins, but by means of the anal area [of the hind-wings] being specialised and at least partly turned upwards in the former, and unspecialised and bent downwards in the latter." The condition in which 1*b* is present, as in all other butterflies, is certainly more primitive than that in which it is reduced or absent.

The occurrence of a basal cell is a fundamental attribute of the family. This is established by the fact that, though it may be much reduced, it is never absent. It must have been well developed in the ancestral PAPILIONIDAE;

[4] Omitting *Chilasa* Moore, which Talbot treats as a separate genus.

for not only is the basal cell generally a conspicuous feature, but it is especially wide in the primitive Cressidini. Though narrow in some of the higher PAPILIONINAE, and in two genera of the ZERYNTHIINAE, it can be described as vestigial only in the PARNASSIINAE, a highly specialised subfamily.

All PAPILIONIDAE possess a precostal vein on the hind-wings. I am convinced that its primitive condition is that in which it ends in a fork. Where one arm only of this fork is preserved, this is generally the distal one but, in these circumstances, a trace of the basal arm can be detected in constantly recurring instances.

(2) *Wing shape.*

The presence of a tail, supported by vein 4 of the hind-wings, must be regarded as an ancestral characteristic of the family. Though such tails are found here and there in other Rhopalocera, it is in the PAPILIONIDAE that they reach their most notable development, as is indicated by the popular English name (" Swallow tails ") applied to the chief subfamily of these butterflies. The tail has been lost independently in many species and groups of species. Indeed the sexes and forms of the same species may differ in the presence or absence of tails, when their loss is often associated with mimicry (e.g., *Papilio dardanus* Brown). The presence or absence of the tail may even be under unifactorial control (e.g., *Papilio memnon* L.).[5] Very possibly tails may have been reacquired by some species after they had disappeared.

(3) *Antennae.*

The primitive structure of the antennae of the PAPILIONIDAE can hardly be in doubt. It must be the one, normally regarded as characteristic of the family, in which they are relatively short and stout, while the club is elongate, gradually thickened, and curved. For, excepting the mono-specific BARONIINAE, such antennae are found in every subfamily and tribe and they are almost universal in the great assemblage of the PAPILIONINAE. It is particularly noteworthy that even in the groups in which the antennae are usually of a different shape, this one appears in those genera judged on other grounds to be primitive (e.g., *Archon* in the PARNASSIINAE, *Lühdorfia* in the ZERYNTHIINAE). Moreover, it occurs in the most primitive genus of all, *Euryades*, though the club has become straight in *Cressida*, the other and more specialised genus of the Cressidini.

The antennae of the Lepidoptera may be scaled, at least dorsally, or non-scaled, except for the basal joints. Jordan (1898), who was the first to make a thorough comparative study of the antennae of this Order, points out that the number of species of the Lepidoptera possessing non-scaled antennae is very small compared with those having the scaled type. On the whole, non-scaled antennae are relatively more frequent in the specialised groups, while the antennae of the PIERIDAE, to which family the PAPILIONIDAE are most nearly allied, are invariably scaled. We may therefore regard the scaled antenna as the more primitive one; yet these scales have been lost in all PAPILIONIDAE except in the genera *Lamproptera* and *Graphium* and the subfamily PARNASSIINAE (in which they occur in all three genera). Curiously enough, these are all highly specialised groups, but it is not uncommon to find a primitive character remaining in species which are otherwise highly evolved.

[5] For a summary of this subject, see Ford, 1937.

(4) *The palpi.*

It is characteristic of the PAPILIONIDAE that the palpi are short. Doubtless this is the primitive condition, for they are long only in the somewhat specialised ZERYNTHIINAE and in the highly specialised *Teinopalpus*, in which latter they are produced to an extravagant degree.

(5) *Genitalia.*

We do not possess sufficiently detailed accounts of the genitalia throughout the family to include these organs among the criteria upon which phylogeny can be based. Gosse (1883) investigated the male clasping organs only. He examined but 69 species, and these are restricted to the genera *Troides*, *Atrophaneura*, *Papilio*, and *Graphium*. Neither his conclusions, nor those of subsequent authors who have made similar studies, clearly indicate that special characters of classificatory significance are associated with particular genera. The extensive work of Mehta (1933) deals with the structure of all parts of the male genital organs, but in the PAPILIONIDAE he dissected only *Papilio demoleus* L., *Cressida cressida* Fab., and *Parnassius epaphus* Bdv. Eidmann (1930) made a detailed examination of the female genitalia of *Troides* (1 species), *Atrophaneura* (2 species), *Papilio* (4 species), and *Graphium* (3 species). It is clearly impossible to base any general conclusion on so small a sample, but his work at least suggests the existence of minor features characteristic of the Troidini, the Papilionini, and the genus *Graphium*.

In general, it appears that the harpes and the scaphium are unusually well developed in the male genitalia of the PAPILIONIDAE. It is certainly possible that these structures were already conspicuous features in the common ancestor of the family.

(6) *The female "pouch."*

In certain species a horny pouch, of diagnostic shape, is carried by the female after copulation, attached to the under side of the abdomen. It is produced by the seminal fluid of the male. I am of opinion that such a pouch was formed in the ancestral PAPILIONIDAE, for it occurs today in one or two genera of all the subfamilies (except the mono-specific BARONIINAE). That is to say, PAPILIONINAE (the primitive *Euryades* and *Cressida*), PARNASSIINAE (*Parnassius*), ZERYNTHIINAE (*Lühdorfia*). Moreover, the existence of a vestigial pouch in *Atrophaneura proneus* Hb., is an additional reason for suspecting that the non-pouched genera descend from pouched ancestors.

(7) *Pigmentation.*

The red pigments of the PAPILIONIDAE are of type A, except in two specialised genera, *Battus* and *Papilio*.[6] Here they are of type B, which is not known elsewhere in the Lepidoptera (Ford, 1944). On the other hand, type A is widely distributed in the Order (*ibid.* p. 94), so that we have good reason for supposing it to be the primitive red pigment of the PAPILIONIDAE. Its occurrence in *Papilio rumanzovia* Eschsch. and *P. deiphobus* L. (Ford, *loc. cit.*) is presumably secondary, for there is no other indication that these are primitive species of their genus.

Anthoxanthin pigments are, on the whole, rather infrequent though widespread in the Lepidoptera (Ford, 1941). Their presence seems to be a primitive feature of the PAPILIONIDAE, as the following considerations suggest. They

[6] And in *Graphium podalirius* L.

are found in several but distantly related genera (Ford, 1944), as if preserved here and there in the family. Thus they may certainly be regarded as characteristic of *Graphium* and are universal in *Parnassius*. In both these genera the amount of anthoxanthin is large, and it has no doubt become important in pigmentation. But anthoxanthins occur also in certain species of *Atrophaneura* and of the Cressidini. Here the quantities are quite small, and they may be only a relic in these more primitive genera. The nearest allies of the PAPILIONIDAE are the PIERIDAE. This is a family in which anthoxanthins can be demonstrated, but they are almost restricted to the DISMORPHIINAE (Ford, 1941), which appear to be a primitive group. Anthoxanthin pigments may therefore have been present in the common ancestor of the PIERIDAE and the PAPILIONIDAE.

(8) *The early stages.*

In the following discussion of the primitive characters of the larvae and pupae of the PAPILIONIDAE, it will of course be understood that the BARONIINAE are omitted throughout, since the early stages of *Baronia brevicornis* Salvin are unknown.

(α) The larvae.

I am inclined to think that the larvae of the primitive PAPILIONIDAE were provided with fleshy tubercles. The evidence for this is not conclusive, but such tubercles are universal in the two most primitive of the tribes, the Cressidini and the Troidini.

The existence of an extensible forked fleshy process on the prothorax may certainly be regarded as a primitive character of the larvae of the PAPILIONIDAE, for it occurs in all three subfamilies. This structure, called the osmaterium, is connected with a scent gland.

It seems probable that the PAPILIONIDAE originated as a group of Aristolochia feeders, relying for protection on poisonous qualities derived presumably from these plants. One or more genera of " Aristolochia Butterflies " are to be found in all three subfamilies. All those genera which, on other evidence, appear to be primitive have this food-plant, as well as some of the more specialised groups (the ZERYNTHIINAE). The more highly evolved species developed, probably independently, a powerful flight. To this the rather slow-flying genera *Parnassius* and *Hypermnestra* are exceptions. They must have evolved distasteful qualities of a distinct kind, if those of the Aristolochia feeders are really acquired from their food-plant.

(β) The pupae.

There can be no doubt that the ancestral PAPILIONIDAE attached their pupae to plants by means of the cremaster and supported them head-upwards by a silken girdle, for this method is employed throughout the family except in the PARNASSIINAE. Furthermore, the PIERIDAE (and some other groups) pupate in this manner also, and they are the family most nearly allied to the PAPILIONIDAE. Doubtless the common ancestor of both families pupated in this way. The peculiar method of pupation (in a cocoon in or on the ground) found in all three genera of the PARNASSIINAE is certainly a specialisation in that subfamily. Indeed it is one of great rarity in the Rhopalocera, though common in some other groups of the Lepidoptera. Perhaps it is an adaptation to the glacial or alpine conditions in which the PARNASSIINAE very possibly evolved, and in which they generally live today.

(*b*) Phylogeny.

I divide the family PAPILIONIDAE into four subfamilies: PAPILIONINAE, ZERYNTHIINAE, PARNASSIINAE, and BARÓNIINAE. The first of these is not only much the largest numerically but it includes a greater range of forms than do the others, for it contains both the most primitive and the most highly specialised genera. Yet these are so naturally connected by intermediates that they represent the end terms of a fairly gradual series. For this reason they cannot be separated into different subfamilies. The ZERYNTHIINAE and the PARNASSIINAE, on the other hand, are each so relatively distinct as to require separate treatment.

Subfamily PAPILIONINAE.

This subfamily contains the following tribes and genera.

Tribe Teinopalpini (genus, *Teinopalpus*).
Tribe Papilionini (genus, *Papilio*).
Tribe Graphiini (genera, *Lamproptera*, *Graphium*).
Tribe Troidini (genera, *Battus*, *Troides*, *Atrophaneura*).
Tribe Cressidini (genera, *Cressida*, *Euryades*).

These are here arranged, as is customary in entomological works, from the more highly specialised downwards to the more primitive, so far as this is possible in a linear series (see p. 222). It will, however, be convenient in the account which follows to consider them in the reverse order, taking the most primitive first.

The following characteristics of the subfamily require mention from the present point of view. On the fore-wings vein 9 is always present, and there is a well-developed median spur except in *Teinopalpus*, where it is rudimentary. There is a fold along the anal margin of the hind-wings. This is rudimentary in the Cressidini, and lost in *Teinopalpus*. The species are tailed or tailless. Anthoxanthin pigments may be present or absent, and the red pigments may be either of type A or type B. A horny anal pouch, borne by the female after copulation, is present or vestigial in the more primitive members of the group only. The larvae of the more primitive genera feed on Aristolochia and are provided with fleshy tubercles; these fleshy tubercles are lost, and the food is not Aristolochia, in the higher forms. The pupae are attached to plants head upwards by means of the cremaster and a silken belt.

Tribe Cressidini.

It is not difficult to determine which group of the PAPILIONINAE (and of the whole family) contains the largest number of primitive characters. This is the Cressidini. On the fore-wings all twelve veins are free and the median spur is well-developed. On the hind-wings the basal cell is large, and there is a distinct trace of vein 1*b*. The anal fold is rudimentary, for this is a character of the PAPILIONINAE rather than of the family as a whole. The red pigments, present in each of the three known species, are of type-A. The female possesses a horny pouch after copulation. The larvae bear fleshy tubercles and feed on Aristolochia. The pupae are attached to plants by means of a cremaster and girth. Moreover, the distribution, Australia and South America, is characteristic of primitive forms (as in the Marsupialia, and in the Dipnoi—with the addition of *Protopterus* in Africa). I am thus in agreement with the opinion expressed by Staudinger, Schatz and

Röber (1892) that *Euryades* and *Cressida* (*Eurycus*) are related and ancestral genera, a view which has received strong support from further analysis.

The tribe Cressidini contains two genera, and of these the South American *Euryades* Felder is more primitive than the Australian *Cressida* Swainson. For *Cressida* possesses no primitive character which does not occur in *Euryades*. On the other hand, five primitive characters absent from *Cressida* are found in *Euryades*. These are : the presence of anthoxanthin pigment in *E. corethrus* Bdv., the occurrence of tails in *E. duponcheli* Luc., and the existence in both species of a forked precostal vein, of antennae in which the club is not only gradually thickened but curved, and of anal claspers. These are aborted in *Cressida*, a condition reached independently elsewhere in the family (*Atrophaneura* species of the Hector Group).

From this tribe are derived in close sequence the Troidini. So too are the Zerynthiinae and the Parnassiinae, but the intermediate forms which once led to them are no longer in existence, leaving them as distinct subfamilies.

Tribe Troidini.

The tribe Troidini is clearly the most nearly allied to the Cressidini. It possesses the same primitive characters, with the following exceptions. The female " pouch " is absent, save in a very few species (e.g., *Atrophaneura proneus*) in which it is vestigial. On the hind-wings the basal cell is narrower, while the anal fold is highly developed. It should be added that the antennae are nearly always of the primitive type with the club gradually thickened and curved.

The Troidini, containing the largest of all Rhopalocera, are usually placed at the head of the family. This is quite a mistake, for they constitute a primitive group, in which *Atrophaneura* and *Troides* are the most generalised. It does not seem profitable to discuss whether the Oriental or the American species of *Atrophaneura* resemble the ancestral form the more closely. They are extremely similar in these two regions. The American species are, from one point of view, the more primitive since a trace of anthoxanthin pigment and a vestige of the pouch occur in some of them : from another they are less primitive, because the tarsal claws of the Cressidini resemble those of the Old World rather than of the New World *Atrophaneura*.

Troides Hb. is very nearly allied to *Atrophaneura*, but the venation of its hind-wings is the more primitive, for vein 1*b* is better developed than in *Atrophaneura*, in which, however, a distinct trace of it is always present at least towards the base (Zeuner, 1943). Yet the great size of *Troides* and the method of pupal attachment, by means of silken threads fastened separately to the pupa instead of by a definite girth, are specialisations. It is therefore doubtful which should be regarded as the more primitive genus, nor is the matter of much importance since the two are so nearly at the same evolutionary level. *Battus* is a more distinct genus and has departed much further from the ancestral Troidini than has *Troides* and *Atrophaneura*, as the list of its characters on p. 203 demonstrates, and it contains the most specialised of the Troidini.

Introduction to the Graphiini and the Papilionini.

The Graphiini, and the Papilionini (leading to the Teinopalpini), must have been derived from some ancestral stock within the Troidini, and the main course of their subsequent evolution must have been independent. So much

appears certain, but the process of their early specialisation is obscured by imperfect and somewhat conflicting evidence. The fact that *Battus* (p. 211) and *Papilio* use red pigment B strongly suggests that the two arose from a common ancestor in which this had been developed. For, unlike type A which has occurred in a number of distinct groups of the Lepidoptera and must have done so independently, type B has never yet been detected outside these two genera (save in *Graphium podalirius*). On the other hand, the dorsal and ventral spines on the tarsi of the Graphiini and the Papilionini are separated by an impressed spineless space, suggesting that the two tribes arose from a common ancestor in which this condition had become established, for it is not found in the Troidini. This would indicate either that the tarsal specialisation had been lost in *Battus*, or else that pigment B had been evolved in the common ancestor of the Papilionini and the Graphiini and that type A had later been substituted in the latter group, so that they possess it independently of their ancestors the Troidini.

I am inclined to favour this latter alternative, and for several reasons. As already mentioned, type B is actually still found in a single species of *Graphium*. As this is its only known occurrence outside *Battus* and *Papilio*, it is more reasonably attributed to a common than to a separate origin. On the other hand, it is known not only that red pigment of type A has frequently arisen independently, but that it has actually displaced type B in two species of *Papilio* (p. 211). This is the very situation suggested for the ancestor of the Graphiini.

In both the Graphiini and the Troidini there is found in the male an anal fold containing a scent organ, a structure absent from the Papilionini. But this must merely mean that a feature developed in the ancestral Troidini has been lost in the Papilionini, though retained in the slightly less specialised tribe Graphiini.

Thus in fig. 1 (p. 222) I have adopted the view just outlined, giving *Battus* a joint origin with the ancestor of the Papilionini and the Graphiini, though I regard it as a somewhat tentative one. The main proposition that these two tribes originated in some way from the Troidini and then diverged, appears well established.

Tribe Graphiini.

The primitive features of the Graphiini are the following: There is a strong median spur on the fore-wings. On the hind-wings the basal cell is well developed, though rather narrow,[7] and vein 1*b* persists though it is very narrow. The antennal club is gradually thickened and curved, but it tends to be a little more abrupt than in the other PAPILIONINAE. The antennae and legs are scaled. Red pigments are always of type A (except in *G. podalirius* L.), and anthoxanthin pigments are present in the great majority of the species. Though the existence, on the hind-wing of the male, of an anal fold containing a scent organ is not a primitive condition in the family, it is characteristic of this tribe and of the relatively primitive Troidini, suggesting that the two groups are somewhat nearly related. However, several specialisations are found throughout the tribe (and others in one of its two genera). The curious kite-like shape is a fundamental feature of the Graphiini; it seems only to be lost secondarily, as in the mimetic species. The larvae have lost the fleshy tubercles, and the habit of feeding on Aristolochia.

[7] The basal cell is consistently wider in the African than in the Oriental or the American species.

The genus *Graphium* Scopoli has the normal short antennae of the Papilioninae, while the cell in the hind-wings is of a size usual in the family. Its particular specialisations relate to venation. Vein 11 generally fuses with 12.[8] It does so in all those of the Old World but five, also in some of the American species, though in these it is more generally free. Sometimes 10 and 12 also fuse.

The genus *Lamproptera* Gray is the highest specialisation of the Graphiini. It contains two known species only, both Oriental, and their shape, with the enormous development of tails, is but an extreme exaggeration of that typical of *Graphium* itself, which they resemble also in possessing scaled legs and antennae and anthoxanthin pigment. This chemical similarity was of course unknown when Jordan (1908–9) suggested that *Lamproptera* (*Leptocircus*) is derived from *Graphium* (*Cosmodesmus*). Consequently the discovery of anthoxanthins in both genera (Ford, 1938) provides noteworthy independent evidence for his view. The anal fold on the hind-wings of *Lamproptera* is large and contains the characteristic male scent organ in *L. curius* F. but not in *L. meges* Zink. The genus differs from *Graphium* in the long antennae, a remarkable specialisation in the Papilionidae. Also in the very small size of the cell of the hind-wings, while vein 11 on the fore-wings is free. *Lamproptera* seems to have been developed from some form ancestral to the Payeni Group of *Graphium* (but not from either of its existing species, which have lost the anthoxanthins). For this is the only Old World group of *Graphium* containing no species in which veins 11 and 12 are fused, while the tarsal claws are similar to those of *L. curius*. *L. meges*, which has lost these claws, as well as the male scent organ, is the most specialised species of the Graphiini.

Tribe Papilionini.

The Papilionini are a highly evolved tribe comprising the single genus *Papilio* L., numerically the largest in the family. They must be derived from the Troidini, but independently from the Graphiini, for their specialisations are of quite a distinct kind. Thus they have not the kite-like shape, while the antennae and legs are unscaled and vein 11 is always free. Though evolved from the Troidini in parallel with the Graphiini, the Papilionini are certainly the more specialised. This is indicated by the loss of four features which must be judged primitive in the Graphiini. These are: (1) anthoxanthins, which are never found in the Papilionini. (2) Vein 1*b* on the hind-wings, which is nearly always absent from this tribe. (3) The male scent organ, common to the Graphiini and the Troidini; for in the Papilionini the anal margin of the hind-wings is simply bent down. (4) Red pigment of type A, which is replaced by the rare type B, save only in *P. rumanzovia* Eschsch. and *P. deiphobus* L. Here it must have been acquired secondarily, for these two species are not primitive in other respects. Thus in a linear arrangement, starting with the most specialised forms, the Papilionini should precede the Graphiini.

In the Papilionini the basal cell of the hind-wings is well developed though rather narrow. It is on the average wider in the African species than in those from other regions. The whole tribe possesses short stout antennae, with the club gradually thickened and curved. As in the Graphiini, the larvae are without the more primitive fleshy tubercles and the habit of Aristolochia feeding has been lost. On the wing, such species must rely for protection on their rapid flight and adroit movements, or on mimicry.

[8] *G. bellerophon* Dalm. is the only species of the Papilionidae in which vein 11 is absent.

Tribe Teinopalpini.

The tribe Teinopalpini contains but a single genus and species, *Teinopalpus imperialis* Hope.* It is, I believe, derived as an extreme specialisation from the Papilionini. This is indicated by the following considerations. The antennae and legs are without scales. The wing-venation is similar to that of *Papilio*, with one important exception. This is the apparent absence of the median spur on the fore-wings, which is strongly developed in all other PAPILIONINAE. However, careful inspection on the underside reveals on the cell a vestigial stump of this spur, indicating that *Teinopalpus* is derived from species possessing it. As in the Papilionini, anthoxanthins do not occur. Unfortunately *T. imperialis* is without red pigment (see Ford, 1944). The antennae are of the form typical of the PAPILIONINAE (p. 210). The larva, which is but little known, is described as of the *Papilio* type, smooth and with a large head. It is supposed to feed on a species of *Daphne*. Since the perfect insect lacks the protection derived from a larval diet of Aristolochia, its flight is exceedingly fast and powerful. It is known that the pupa is attached to plants by the cremaster and a silken girth. The specialisations of *Teinopalpus* additional to those of the Papilionini are the loss of the median spur (already mentioned), the great enlargement of the palpi and the occurrence, unique in the subfamily, of a second pair of tails, at vein 6, in the female only. This genus represents the highest development of the family PAPILIONIDAE.

Introduction to the subfamilies ZERYNTHIINAE and PARNASSIINAE.

We now reach two subfamilies, the ZERYNTHIINAE and the PARNASSIINAE, which have diverged from some ancestral member of the PAPILIONINAE at a level but little more advanced than that of the Cressidini. This is suggested by the fact that they possess primitive characters which have already been lost or become vestigial in the Troidini. Thus a well-developed pouch is formed after copulation in the females of all species of *Lühdorfia* and *Parnassius*, while no sign exists of the anal fold and male scent organ on the hind-wings, which is such a characteristic feature of the Troidini. On the other hand, primitive features absent from both the subfamilies under consideration are to be found in the Cressidini. The presence of a well-developed median spur on the fore-wings, of vein 1*b* on the hind-wings, and of large fleshy tubercles in the larvae, may especially be mentioned here.

The ZERYNTHIINAE and the PARNASSIINAE have evolved upon divergent lines, for their specialisations are of very different kinds. They are more extreme in the latter subfamily. Thus it comes about that the ZERYNTHIINAE retain more features in common with the primitive PAPILIONINAE than do the PARNASSIINAE. Yet the PAPILIONINAE are so large and diverse a group that it includes tribes which must be judged respectively more primitive and more highly evolved than either the ZERYNTHIINAE or the PARNASSIINAE.

Subfamily ZERYNTHIINAE.

This subfamily contains four genera. It has a number of primitive features. All twelve veins are invariably present and free in the fore-wings. A trace of the median spur remains in two of the genera (*Sericinus* and *Bhutanitis*).

* A second species of *Teinopalpus* has been described, as *aureus* Mell. But as its specific status does not seem to have been fully established, I have treated it as a subspecies of *T. imperialis*. This genus is therefore allotted but a single species both here and in Ford, 1944.

On the hind-wings the pre-costal vein is forked in *Lühdorfia* and *Sericinus*, while the basal cell is wide in *Sericinus* and *Bhutanitis*, though it is narrow in the other two genera. A tail, or at least a well-marked tooth, is always formed at vein 4. In *Lühdorfia* only, the female bears a horny pouch after copulation. The red pigments are invariably of type A. The larvae feed on Aristolochia.[9] They are short and thick and possess the osmaterium. In *Sericinus* and *Zerynthia* they bear fleshy tubercles set with hairs. These are so much reduced compared with those of the Troidini and the Cressidini that they may well be distinct structures not homologous with them. The pupae are attached to plants by a cremaster and girth, as in the PAPILIONINAE. The girth may, however, be absent or reduced to a few threads only, and support derived from extra threads attached at the head.

The specialisations of the ZERYNTHIINAE are not numerous. The palpi are long, the median spur is vestigial or absent, and anthoxanthins are never found. Extra tails or dentations are formed in *Bhutanitis* and *Zerynthia*. The pupa is of a form exceptional in the family; for it is remarkably slender, except in *Lühdorfia*, where it is stout, as in the PAPILIONINAE.

The most primitive genus of the ZERYNTHIINAE appears to be *Lühdorfia* Crüger, 1878, of which two species are known. It alone possesses the horny pouch in the female. The antennae are of the form typical of the family (p. 210). The pre-costal vein is forked, and the hind-wings are provided with (short) tails. The pupa is stout, as in the PAPILIONINAE, and it is fastened to the food-plant by a girdle and the cremaster, but there are also some threads of silk attached to the head and thorax. A few specialisations appear to be associated with this genus. No trace remains of the median spur, and the basal cell is narrow. The larvae have not the fleshy tubercles which exist in *Sericinus* and *Zerynthia*, if indeed these be primitive (see above). If the fleshy tubercles of the ZERYNTHIINAE are a separate development, their absence from *Lühdorfia* is a relatively primitive rather than a specialised feature.

The information on the early stages of *Lühdorfia* that is available in text-books is very imperfect. I am therefore much indebted to Dr. K. Jordan, F.R.S., for his kindness in examining the larvae and pupae preserved in the Rothschild collection at Tring and sending me an account of them.

Sericinus Westw., 1851, is the next most primitive genus to *Lühdorfia*. It possesses a minute trace of the median spur on the fore-wings. On the hind-wings, the pre-costal vein is forked, the basal cell is wide, and there are long tails. The larvae have small fleshy tubercles, though indeed these may not be primitive. The pupa possesses a well-developed silken girdle. Its specialised characters are the following. The antennae are highly modified, being weak and thread-like, with a straight club. The female is without the horny pouch after copulation, and the pupa is slender.

The genus *Bhutanitis* Atk., 1873 (= *Armandia* Blanch., 1871 praeocc.), of which four species are now known, retains a trace of the median spur, and the basal cell of the hind-wings is wide. It displays several specialisations. The antennae are highly modified and thread-like, though the club is curved as in the primitive condition. The females have no horny pouch after copulation, and the pre-costal vein is not forked. The species have attained a larger size than have the other ZERYNTHIINAE. They have a long tail at vein 4, and have developed additional shorter ones at veins 2 and 3. The early stages are unknown, but the larvae are presumed to feed on Aristolochia.

Zerynthia Ochsenh., 1816 (= *Thais* F., 1807 praeocc.) is a genus of three

[9] In discussing the early stages, it must be noted that those of *Bhutanitis* are unknown.

known species. The antennae are of the shape characteristic of the family (p. 210), while the larvae possess short fleshy tubercles (see p. 218). Its chief specialisations are the following. There is no trace of the median spur on the fore-wings, the basal cell of the hind-wings is narrow, and the pre-costal vein is not forked. The female is without a horny pouch after copulation. The tails are reduced to deeply-marked dentations. The pupae are slender and the girdle is generally, but not invariably, absent. Extra threads are attached to the head.

The ZERYNTHIINAE have diverged along two distinct lines, though these do not appear to be sufficiently dissimilar to warrant their separation into different tribes. Their specialisations are in opposite directions. *Lühdorfia*, the most primitive genus of the subfamily, has branched from the line leading to *Zerynthia*, which is the most highly specialised genus. In both, the antennae are of the form characteristic of the family. No trace remains of the median spur, and the basal cell of the hind-wings is narrow. There is a reduction in size and in tail-length. All the known species of both genera are considerably below the average dimensions of the family. The tails are short in *Lühdorfia*, and reduced to dentations in *Zerynthia*.

On the other hand, the line including *Sericinus* and *Bhutanitis* is marked by the reverse set of modifications. The antennae are highly specialised. A vestige of the median spur persists, and the basal cell of the hind-wings is wide. There is an increase in size and in the development of tails. *Sericinus*, the more primitive genus of the two, is larger than either *Lühdorfia* or *Zerynthia* and its tails are always long, in some forms extraordinarily so. The more specialised *Bhutanitis* contains much the largest species of the subfamily, and conspicuous tails are developed at veins 2 and 3, in addition to a large tail in the usual position.

Lühdorfia and *Sericinus* therefore represent the relatively ancestral genera of their respective lines, and *Lühdorfia* is the more primitive of the two. The two specialised genera, *Bhutanitis* and *Zerynthia*, have both lost the fork at the end of the pre-costal vein. *Zerynthia* has fewer primitive characters than has any other genus of the ZERYNTHIINAE.

Subfamily PARNASSIINAE.

As already indicated, this is a much more highly specialised subfamily than the ZERYNTHIINAE. It contains three genera, and the species have the lazy flight of protected insects, though *Archon* alone feeds on Aristolochia. They have a few primitive features. The palpi are short, the antennae are scaled, and the red pigments are always of type A. The larvae possess the osmaterium. Females of *Parnassius* develop the horny pouch on the abdomen after copulation, while anthoxanthin pigments are invariably present in this genus.

The specialisations of the PARNASSIINAE are striking, and mainly upon lines different from those of the ZERYNTHIINAE. The antennae are modified from the primitive form (p. 210) except in *Archon*. No trace remains of the median spur on the fore-wings, and on the hind-wings the basal cell is extremely narrow, indeed rudimentary, though always present. The pre-costal vein is never forked. Tails have been completely lost, and the costal and outer margins form a smooth continuous curve. The larvae are cylindrical, without fleshy tubercles; but it is in the pupal stage that the most remarkable specialisation of the PARNASSIINAE is encountered. All other members of the family pupate as do the PIERIDAE, but the pupae of the PARNASSIINAE are formed

within a cocoon in or on the ground, a very exceptional condition in the Rhopalocera. Further, they are immovable, while in those of the ZERYNTHIINAE the abdominal segments are free and are actively moved.

The PARNASSIINAE are typical alpine species of the Palaearctic Region, though three have made their way from north-east Asia into North America. They have evolved either as mountain butterflies or else during an ice age, having subsequently retreated to the mountains with the onset of warmer conditions. We have nothing to indicate which of these two alternatives is correct. It is true that a few species are found at low elevations in the northern part of their range (*e.g.*, Eastern Germany), but whether they have remained in such situations or spread to them from a mountain habitat, we have no means of knowing. The only member of the subfamily which inhabits warm localities, plains as well as mountains, is *Archon*, found in Palestine, Asia Minor, the Greek Islands, and similar habitats. If, as I suspect, the peculiar method of pupation of the PARNASSIINAE arose as an adaptation to ice-bound conditions in the winter, then *Archon* must have become specialised secondarily to its present type of environment.

The most primitive genus of the PARNASSIINAE appears to be *Archon* Scudder, 1875, containing one living and one known fossil species. For it, alone in the subfamily, possesses all 12 veins on the fore-wings and the typical antennae of the PAPILIONIDAE, while the larva feeds on Aristolochia. Its specialisations, compared with *Parnassius*, are the absence of anthoxanthin pigments and of the horny pouch.

Parnassius Latreille, 1805, is a little more specialised than is *Archon*, and seems to have evolved upon somewhat different lines. Its primitive characters are the presence of anthoxanthin pigments and of the horny pouch in the female. The genus has a number of specialisations. Vein 9 is absent from the fore-wings. The distal vein of the rudimentary basal cell of the hind-wings is exceedingly thin. The scales are exceptionally heavily chitinised. The antennal club is not curved, though the antennae are of the form characteristic of the PAPILIONIDAE in other respects. The larvae have lost the habit of feeding on Aristolochia. Their food-plants are, in fact, rather diversified: *Saxifraga*, *Sedum*, *Sempervivum*, *Scabiosa*, and others.

There can be no doubt that *Hypermnestra* Mén. 1845, containing the single species *H. helios* Nick., is the most highly evolved genus of the PARNASSIINAE. It appears to have originated from some ancestral *Parnassius* and, as in that genus, vein 9 is absent. Its scales are not exceptionally chitinised. Other than this, its only primitive characters are those mentioned on p. 219 as features of the whole subfamily. In its specialisations it may be contrasted with *Parnassius*. The antennae end in a short abrupt knob, somewhat flattened, a unique and most unexpected condition in the PAPILIONIDAE. Anthoxanthins are absent, as is the horny pouch of the female. The larva feeds on *Zygophyllum turcomanicum*.

Two diverging lines are encountered within the PARNASSIINAE. These are represented on the one hand by *Archon*, which is also the most primitive genus, and on the other by that leading to *Parnassius* and *Hypermnestra*. *Archon* has specialised in the direction of using pigments other than anthoxanthins and in discarding the horny pouch. The *Parnassius* and *Hypermnestra* line has modified the venation of the fore-wings; also the shape of the antennae, though in varying ways.

Stichel (1907) says that *Archon* (= *Doritis* F.) is in structure and pattern a natural transition from *Zerynthia* (= *Thais*) to *Parnassius*. I can see no

justification for this view. Such primitive characters as these three genera possess they have in common, as they have with any primitive member of the PAPILIONIDAE. But *Zerynthia* has not a single feature suggesting that any of the specialisations of the PARNASSIINAE as found in *Archon* have been evolved in its ancestors. Nor has *Archon* any sign of the specialisations of the ZERYNTHIINAE; naturally not those of its most specialised genus, *Zerynthia*. There is no evidence at all to suggest that *Archon* is an intermediate form between *Zerynthia* and the other PARNASSIINAE. Everything indicates that these two subfamilies arose independently from species belonging to the primitive PAPILIONINAE.

Subfamily BARONIINAE.

The BARONIINAE include a single genus and species only. This is the rare and remarkable *Baronia brevicornis* Salvin, 1893, from a few remote localities in the mountains of Mexico. Its flight is lazy as in protected forms, but its food-plant is unknown. The characters of this species are of a most remarkable kind to warrant, as they apparently do, its separation into a distinct subfamily. Yet it possesses a few primitive features. The palpi are short. On the hind-wings the pre-costal vein is forked, and the basal cell is wide.

The specialisations of *Baronia* are numerous and striking. The antennae are extraordinarily short, with a straight broad club. The female is without the horny pouch. On the fore-wings vein 9 is absent, and 11 fuses with 12. There is no trace of the median spur. The hind-wings are without tails or dentations. It seems almost certain that anthoxanthins are absent. The paler markings are, however, of rather a deep yellow shade, so that the ammonia test would only be effective if the quantity of anthoxanthin were fairly considerable, and the species is as yet too rare in collections to allow of specimens being sacrificed for extraction with ethyl acetate (for these tests, see Ford, 1941). Unfortunately there is no red pigment in *Baronia brevicornis*. The colour-pattern is unique among the PAPILIONIDAE, for the under surface is marked with spots of silver-white, recalling an *Argynnis*.

We lack the data necessary to decide the affinities of *Baronia*, since its early stages are unknown. Jordan (1907–8) says that it " belongs in the neighbourhood of *Parnassius*." Quite possibly it is more nearly allied to the PARNASSIINAE than to any other living group, but the evidence for such a conclusion is remarkably slender. It consists only in the rounded shape of the hind-wings, though the apex is more marked than in the PARNASSIINAE, and in the absence of the median spur, but this is true also of two genera of the ZERYNTHIINAE so that it may have been reached independently. One striking feature which might have, and perhaps has, also been advanced to support this relationship is the absence of vein 9, for the PARNASSIINAE are the only other members of the family in which it is lost. Yet a little consideration will show that, from the present point of view, this condition is wholly valueless as evidence. For it is a character not of the subfamily PARNASSIINAE but of two genera within it. If we suppose that the loss of vein 9 is homologous in the two groups, we should be driven to consider that *Baronia* had evolved between *Archon* (with all 12 veins) and *Parnassius*, in which vein 9 is lost. It seems scarcely credible that a distinct subfamily should have arisen within so homogeneous a group as the existing PARNASSIINAE. Moreover, the view becomes in the highest degree unlikely when we recall that *Baronia* possesses primitive characters already lost in *Archon* (the forked pre-

costal vein, and the wide basal cell). Logically, we can no more use the absence of vein 9 in *Baronia* as evidence of affinity with *Parnassius*, than we can use the fusion of 11 with 12 as evidence for an entirely impossible affinity with *Graphium* (the only other genus in which this occurs). In fact, we must suspend judgment on the relationship of *Baronia* until information on its early stages is forthcoming.

(c) Conclusions.

My general conclusions on the classification of the PAPILIONIDAE are embodied in fig. 1, which provides a complete survey of them. It will be seen

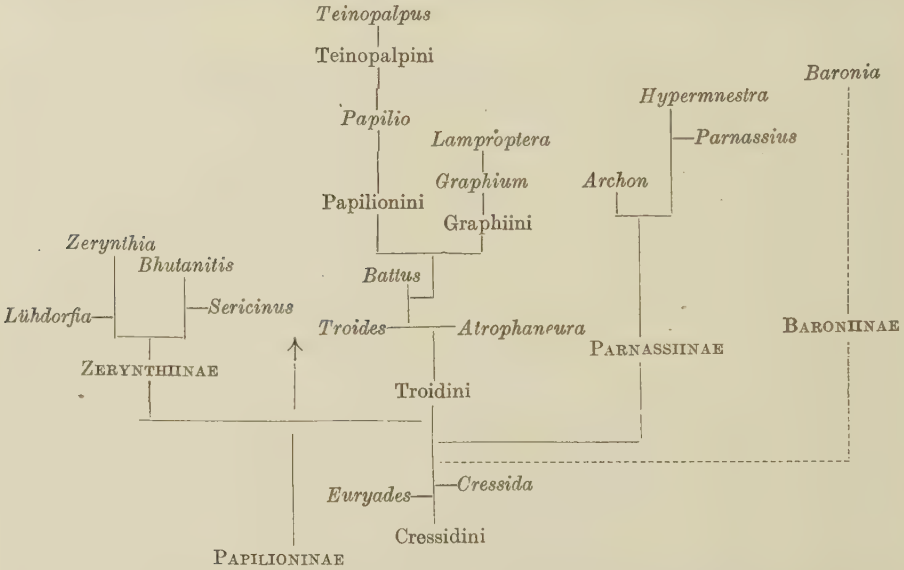

FIG. 1.—The affinities of the sub-classes, tribes, and genera of the family PAPILIONIDAE. The more primitive forms are placed at a lower level than the more specialised. The position of the BARONIINAE is arbitrary.

that a number of diverging lines of specialisation are to be traced within the family. Consequently, the relationships of the genera cannot be represented correctly in a consecutive series. Yet an arrangement of that kind is essential for practical purposes. Several such linear orders, each possessing certain advantages, might be constructed. It is hardly material which out of two or three of them be adopted, since none can reflect the actual condition. That which seems to me the least exceptionable is given in Table 6 of the previous paper of this Series (Ford, 1944). In that work I have discussed some of the difficulties inherent in a consecutive arrangement of the genera of the PAPILIONIDAE.

4. SUMMARY.

1. The " Polydamas Group " of American *Atrophaneura* Reakirt (= *Polydorus* Swainson) must be separated as a distinct genus, for which the name *Battus* Scopoli is available.

2. The genera *Chilasa* Moore and *Agehana* Mats. should be discarded. The species included in both belong to *Papilio*.

3. The genera *Euryades* Swainson (from South America) and *Cressida* Felder (from Australia) should be combined within the subfamily PAPILIONINAE as a tribe, which may be called the Cressidini. *Euryades* is the most primitive genus of the family.

4. I have examined the status of a number of other genera.

5. It seems possible to determine the primitive characters of the PAPILIONIDAE with fair probability. This has been attempted and the results discussed.

6. Using the information so obtained, which includes both structural characters and the data on the chemistry of pigments provided in previous works (Ford, 1941, 1944), I have studied the systematics and phylogeny of the family. My conclusions are embodied in fig. 1.

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THE BEETLES OF THE LAMELLICORN SUBFAMILY VALGINAE, WITH A SYNOPSIS OF THE GENERA AND DESCRIPTIONS OF SOME NEW SPECIES

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Prof. H. J. Kolbe, the only entomologist who has made any comprehensive study of this group, in dealing with African and Malayan forms respectively in 1897 & 1904, *Stett. ent. Ztg.*, raised it to family rank as the Valgidae, the equivalent of the Cetoniidae, of which it had previously been considered a part. He has not given his reasons for this, but the important differences which exist between the two groups and the absence of any known connecting links seem to supply a sufficient justification. It has now become the usual practice to treat the majority of the Lamellicorn beetles as forming subfamilies of a single family, the Scarabaeidae, and I propose to call these groups the Cetoniinae and Valginae.

The very small size and almost invariable clothing of scales are the most obvious characteristics of the Valginae and the elevation of the last pair of spiracles, although also occurring in a few Cetoniinae, reaches its greatest development in these insects; but their principal distinctive feature is the very wide separation of the hind coxae, contrasted with their immediate contact in the Cetoniinae. Another feature, which has been almost unnoticed, is the occurrence of very long terminal hairs upon the maxillae, generally protruding far beyond the mouth, where they form a suctorial brush or tongue. They are short in the few species which constitute the genus *Valgus* and in the females of *Charitovalgus* and *Oreovalgus*. These are the European and Asiatic genera in which the female has a caudal process or stylus. In the African *Cosmovalgus* and *Sphinctovalgus*, in which the process also exists, the maxillary brush is long in both sexes. It may be concluded that, like most Valginae, both sexes of these frequent flowers but that the females of *Valgus*, *Charitovalgus* and *Oreovalgus* do not.

The very remarkable female appendage, a slender rod formed by the production of the extremity of the last tergite, is confined to a small minority of the species, although, in addition to the ancient genus *Valgus*, 7 other genera were formed by Kolbe for their reception. The apparatus is no doubt used in the egg-laying operations, the larvae being found underground in rotting wood. In the European *Valgus hemipterus* the instrument is a little hollowed towards the end and its edges are finely toothed there. In *Charitovalgus scorpio*, here described, there are teeth upon the lower, instead of the upper, surface. There is generally a slight downward curvature but in *Sphinctovalgus* there is an upward curvature.

It might have been supposed that the presence or absence of so peculiar a feature as the caudal style would correspond with natural subdivisions of the

group but, on the contrary, extremely close affinity exists between forms in which the appendage occurs and others in which it is absent. Casey has, not altogether unreasonably, refused to recognise the genus *Homovalgus* Kolbe, of which the two sexes are almost identical, as distinct from *Valgus*, in which they are so conspicuously different.

Five genera, with one exception African, in which the females have a caudal style, were grouped together by Kolbe as constituting the COSMOVALGINAE, distinguished by the situation of the terminal spiracles not at the hind margin of the propygidium but at a distance from it. He did not observe that another African genus formed by himself, in which the female appendage is absent, viz. *Comythovalgus*, which he placed among his DASYVALGINAE, has the spiracles situated as in *Cosmovalgus*, with which it also agrees in having the front tibiae 5-toothed in the male and 3-toothed in the female. His genus *Lobovalgus*, however, must be removed from the *Cosmovalgus* section, since its last pair of spiracles are in the normal situation.

Kolbe divided the whole group into two subfamilies, which he called VALGIDAE *genuinae* and VALGIDAE *ordinis antiqui* and which I shall call the Valgini and Microvalgini. He regarded the concave abdomen of the male as the chief distinguishing feature of the latter division and, in consequence, included in it the very peculiar West African *Sphinctovalgus conradti*, of which the female, unlike those of all other Microvalgini, has a caudal style. A feature overlooked by him, the interposition of the mesosternum between the middle coxae, is, in my opinion, a more important character of the Microvalgini and, as *Sphinctovalgus* agrees in the absence of this with the Valgini, I consider it more naturally placed there, with all other genera in which a caudal process is to be found.

The two sexes of VALGINAE sometimes have little resemblance to one another. Males are nearly always much more abundant than females and females of many are unknown. It is likely that different names have been given to the two sexes of some. In the predominant Oriental genus *Dasyvalgus* most of the now numerous species are at present known from males alone. Amongst the few of which both sexes have been described is the wide-ranging *D. luctuosus* Gestro, the male of which I believe to be *D. dohrni* Kolbe. This species is found in Indo-China, the Malay Peninsula, Java and the Philippine Is. and, although both sexes have been taken throughout that area, they appear never to have been found on the same occasion. The females often differ from the males by their narrower form, less lively colours, the scales replaced to a greater or less extent by stiff setae, especially upon the abdomen, a less development of scale-tufts on the upper surface, less produced terminal spiracles, stouter legs and shorter tarsi. These are, in the main, the characteristics of the genus *Anepsiovalgus* of Kolbe, founded upon a single specimen from Sumatra. This, called *Anepsiovalgus mimus*, will probably be found to be the female of a species of *Dasyvalgus*. The difficulty of correctly associating the two sexes has proved a serious obstacle to the systematic study of this group and is the reason why a certain number of species have not yet been assigned to their proper genera. It is the practice of some entomologists to name a type of each sex of a new species and a specimen taken subsequently to the original description may even be described as the type of the other sex. This proceeding seems more likely to bring trouble than advantage, the designated types of a so-called species undoubtedly sometimes belonging to two entirely different insects.

Having fortunately been able to bring together in the British Museum a

collection of VALGINAE containing, I believe, all the described genera and a larger number of species than has been available to any other systematist, I have drawn up the synoptic table which follows, omitting from it, as synonyms, a few names to which I have been unable to assign any characters of differential value. M. Burgeon has remarked, in his survey of Congo forms, that the distinctive features of *Pygovalgus* and *Cosmovalgus* of Kolbe are, in his opinion, not of generic value and, as the number of known species of these insects increases and the gaps are filled, the abandonment of other generic names may become unavoidable.

Synopsis of the Genera of VALGINAE.

1(48). Mesosternum not interposed between the middle coxae . . . VALGINI.
2(15). Terminal spiracles not at the hind margin of the propygidium.
3 (4). Very elongate; terminal spiracles near the base of the propygidium *Sphinctovalgus* Kolbe.
4 (3). Not very elongate; terminal spiracles between base and hind margin of the propygidium.
5 (6). Hind tibiae greatly swollen . . . . . *Oedipovalgus* Kolbe.
6 (5). Hind tibiae not swollen.
7(14). Pronotum bearing scale-tufts, without median carina.
8(13). Body elongate; pronotum not ovate.
9(10). Scutellum not very long and narrow . . . . . *Oreovalgus* Kolbe.
10 (9). Scutellum very long and narrow.
11(12). Base of the pronotum lobed . . . . . *Pygovalgus* Kolbe.
12(11). Base of the pronotum not lobed . . . . . *Cosmovalgus* Kolbe.
13 (8). Body very short; pronotum ovate . . . . . *Comythovalgus* Kolbe.
14 (7). Pronotum with median carina, without scale-tufts . . *Valgoides* Fairm.
15 (2). Terminal spiracles at the hind margin of the propygidium.
16(21). Basal angles of the pronotum produced.
17(20). Basal angles of the pronotum sharp.
18(19). Pygidium produced into a sharp spine . . . . *Hoplitovalgus* Kolbe.
19(18). Pygidium doubly produced at the end . . . . . *Acanthovalgus* Kolbe.
20(17). Basal angles of the pronotum blunt . . . . . *Euryvalgus* Kolbe.
21(16). Basal angles of the pronotum not produced.
22(37). Front tibia bearing more than three teeth.
23(24). Tarsal joints acutely produced externally . . . . *Lobovalgus* Kolbe.
24(23). Tarsal joints not acutely produced.
25(30). Terminal spiracles not produced.
26(29). Middle coxae not very widely separated.
27(28). Pronotum contracted at the base; female with caudal style. *Valgus* Scriba.
28(27). Pronotum broad at the base; female without caudal style *Homovalgus* Kolbe.
29(26). Middle coxae very widely separated . . . . . *Chromovalgus* Kolbe.
30(25). Terminal spiracles distinctly produced.
31(32). Middle tibia more or less swollen, not toothed at the side *Charitovalgus* Kolbe.
32(31). Middle tibia flattened, with a tooth at outer edge.
33(34). Elytral striae straight . . . . . *Mimovalgus* Arrow.
34(33). Elytral striae sinuous.
35(36). 6th sternite retractile, smooth and shining . . . *Dasyvalgus* Kolbe.
36(35). 6th sternite not retractile and smooth . . . . . *Hybovalgus* Kolbe.
37(22). Front tibia bearing 3 teeth only.
38(47). Terminal spiracles at the sides of the propygidium.
39(42). Propygidium with two scale-tufts.

40(41). Basal segment of hind tarsus short . . . . . *Xenoreoderus* Arrow.
41(40). Basal segment of hind tarsus long . . . . . *Lepivalgus* Moser.
42(39). Propygidium without scale-tufts.
43(46). Pronotum with two longitudinal ridges anteriorly.
44(45). Clypeus simple . . . . . *Oreoderus* Burm.
45(44). Clypeus bidentate . . . . . *Podovalgus* Arrow.
46(43). Pronotum without longitudinal ridges . . . . *Idiovalgus* Arrow.
47(38). Terminal spiracles not at the sides of propygidium . *Chaetovalgus* Moser.
48 (1). Mesosternum interposed between the middle coxae . . MICROVALGINI.
49(52). Scutellum large.
50(51). Front tibia massive, tridentate . . . . . *Stenovalgus* Kolbe.
51(50). Front tibia bearing more than three teeth . . . *Microvalgus* Kolbe.
52(49). Scutellum small . . . . . *Ischnovalgus* Kolbe.

Genus *Oreovalgus* Kolbe.

This genus, confined, according to present knowledge, to Borneo, is remarkable for the fact that it belongs to an otherwise African group of genera, in which the last pair of spiracles are situated in the anterior, instead of the posterior, part of the propygidium. The genotype, *O. montuosicollis* Kolbe, of which only the male has been described, although a female which I believe to belong to it is in the British Museum (N.H.), appears to be the insect previously described by Gestro as *Valgus cristatus*. Gestro evidently noticed the elevation in the species of two pairs of spiracles (" propygidio utrinque bituberculato ") but failed to observe that the anterior pair really occupied the preceding segment. A second species, described from a female alone, is *Oreovalgus sandakanus* Moser. To this I refer a male and a female, taken upon Mt. Dulit, Sarawak, by Dr. B. M. Hobby in August and September 1932. A third species is described here. The three forms differ greatly in external appearance. They agree in having comparatively short front tibiae, armed with four teeth, alternately long and short. The terminal spiracles are more elevated in *O. cristatus* than in *O. sandakanus* and *bryanti*.

Oreovalgus bryanti sp. n.

♂. Black or dark brown, clothed with pale yellow or buff-coloured scales, which are rather close upon the lower surface and legs and upon parts of the pronotum.

Body rather short and compact. Clypeus rugosely punctured, not emarginate in front. Pronotum a little longer than wide, narrow in front, the upper surface bearing a short strongly produced crest on each side in front and between these a nearly flat, rectangular, densely punctured area, produced into two sharp, obliquely prominent angles in front and extending beyond the middle behind. The whole posterior part of the pronotum is densely covered with long erect scales, forming a large rounded cushion on each side. Scutellum short. Elytra rather evenly, not densely, clothed with scales, most of them pale yellow, with a large triangular common patch behind the scutellum and a large oblique posterior patch on each side bearing dark scales. Propygidium and pygidium not very densely clothed with yellow scales, the former bearing two scale-tufts at the hind margin, the latter shortly produced and tufted at the tip. Front tibia 4-toothed, the 1st and 3rd teeth strong, the 2nd broad, the 4th very blunt. Middle and hind tarsi about twice as long as the tibiae.

Length 5·5 mm.

BORNEO : Quop, W. Sarawak, April (*G. E. Bryant*).

A single male specimen. This is smaller and less elongate than the male

of *O. cristatus* Gestro and the legs are less slender. It is also less densely clothed with scales. The form of the pronotum is quite peculiar. The two longitudinal carinae so usually found in the group are absent, although represented by a pair of obliquely prominent processes extending forward above the head. From these a nearly flat rectangular area, densely punctured and almost denuded of scales, extends backwards past the middle of the pronotum. The sides adjoining this area are densely clothed with bright yellow scales and the whole posterior part is covered by two cushion-like bunches of long erect scales. The elytra are short and quadrate. The last two pairs of spiracles are elevated but only slightly.

Genus *Valgus* Scriba.

Although more than a score of species are still recorded under this name, which for long represented the whole group, very few of them actually belong to it. Species truly congeneric with the European *V. hemipterus* L. appear to be known only from North America and Mexico, for there seems to be no doubt that *V. smithi* Macl., ascribed to South Africa, should be eliminated altogether. It is probably a stray European *V. hemipterus*. The discovery of a species of this genus in Indo-China is therefore of great interest. The female, which, as best displaying the generic characters, I regard as the type, was received by myself from M. de Cooman of Tonkin and the male, now also in the British Museum (N.H.), was sent by the same collector to M. Bourgoin, the captor probably having taken the specimens on different occasions and not recognised them as the two sexes of a single species.

Valgus tonkinensis sp. n.

Black, decorated with buff-coloured scales, rather closely aggregated in the front angles and the middle of the sides of the pronotum, at the base and near the apical angles of the elytra and as a short transverse bar before the middle of each. There are scattered pale scales elsewhere and a median longitudinal line may be indicated upon the propygidium and pygidium. The intervals are partly occupied by dark scales, amongst which one or two small round spots may be seen behind the base of each elytron. The lower surface of the female is decorated with scattered pale scales and the abdomen of the male is closely covered with them except at the sides.

Moderately elongate, with slender legs. Head rather broad, rugose, feebly bilobed. Pronotum coarsely punctured, not longer than wide, narrowed in front and behind, bearing two strong and sharp, nearly parallel carinae, rather prominent in front and extending to about the middle behind, the sides rounded, coarsely serrate in front, the base rounded and all the angles obsolete. Elytra not very short, striate, the intervals rugulose. Propygidium bearing two slight scale-tufts at the hind margin. Front tibia armed with 5 sharp teeth, the 2nd and 3rd widely separated. Basal segment of hind tarsus 4 times as long as the succeeding joint.

♂. The pygidium bears two pale tufts at the end.

♀. The caudal spine is long and a little hollowed towards the tip, with 4 or 5 minute teeth on each side of the hollow. Tarsi much shorter than those of the male.

Length 8 mm.

Tonkin: Hoa-binh (*A. de Cooman*).

Valgus tonkinensis resembles the European *V. hemipterus* and is of similar size but the male is a little more elongate and the female a little less so. The scale pattern is also similar but consists of buff-coloured, instead of white,

scales. The pronotum is shorter in both sexes, more rounded at the sides and more contracted at the base. The two sexes are less dissimilar than those of *V. hemipterus*.

Genus *Charitovalgus* Kolbe.

This genus differs from *Valgus* in the more elongate form, longer legs and particularly by the very prominent terminal spiracles. It is remarkable for the greatly differing aspect of the two sexes of some species, which renders it impossible to associate them with certainty unless ample evidence of their specific identity is forthcoming. In dealing, 30 years ago, with two Japanese Valginae of which only one sex was known I referred them "provisionally" to the genus *Chromovalgus* Kolbe. Mr. Sawada, in 1941, *Nippon no Kochu* **4**, placed them in *Valgus* and regarded them as conspecific with the Indian *Valgus pictus* of Hope. Together with that species they really belong to *Charitovalgus*, of which Mr. Sawada has described others. The types of the three forms, *C. pictus* Hope, *fumosus* Lewis and *laetus* Arrow, are in the British Museum and are certainly not conspecific. The males of these and a fourth species nearly related to them may be distinguished as follows :—

1(6). 2nd and 3rd teeth of the front tibia widely separated.
2(3). Pygidium with a yellow median line, lateral margins of the pronotum not coarsely serrated . . . . . *fumosus* Lewis.
3(2). Pygidium entirely yellow, lateral margins of pronotum coarsely serrated.
4(5). Elytra with a sutural band of yellow scales from base to apex . *pictus* Hope.
5(4). Elytra with a basal triangle of yellow scales . . . . . *croesus* sp. n.
6(1). 2nd and 3rd teeth of the front tibia not widely separated . . *laetus* Arrow.

The Formosan insect called by Mr. Sawada *Valgus pictus* var. *taiwanus* appears to agree with *Charitovalgus laetus*.

Valgus keysseri Hauser, from New Guinea, described in 1904, is evidently a species of *Charitovalgus*, of which about a dozen are now known, most of them from one sex only. The remarkably dissimilar male and female of *C. pictus* Hope were described and figured by me in *Fauna of British India*, Coleoptera, Cetoniinae : 246, pl. 2, figs. 10 and 11. A second species from New Guinea is described here.

Charitovalgus croesus sp. n.

♂. Black, with the scutellum and a triangular basal area common to both elytra and extending to about the middle densely covered with bright yellow scales. There are a few white scales on each side of the apex of the yellow triangle and a few more forming a small white spot close to the hind margin of each elytron. The whole of the pygidium and the posterior part of the propygidium are covered with bright yellow scales and the middle of the metasternum and abdomen with greyish-yellow ones.

Elongate, with long slender legs, the front tibia narrow, with its 2nd and 3rd teeth widely separated, the 2nd and 4th very blunt, the hind metatarsus longer than the two succeeding joints together. Head strongly punctured and setose, the clypeal margin notched in the middle. Pronotum longer than wide, closely and coarsely pitted, with two very sharply elevated curved carinae extending from the front margin to the middle, where they converge and bear a pair of black scale-tufts at their extremities. Another pair of tufts occupy the hind angles and there is a sharply elevated tubercle on each side between the carinae and the lateral margins, lateral margins curved, very deeply and coarsely serrated, strongly contracted in front and very slightly at the base, the hind angles well marked but not acute. Scutellum long and narrow. Elytra broad and flat,

with very prominent shoulders. Terminal spiracles of the propygidium minute but prominent, shining, not conical nor scaly.

Length 7 mm.

Tonkin: Muong Sing, Upper Mekong R., April 1918 (*R. Vitalis de Salvaza*).

The type is unique.

Although resembling *C. pictus* Hope rather closely, the scale-pattern of the elytra is quite distinctive. In addition, the sides of the abdomen are continuously black, instead of being decorated with four black spots as in *C. pictus*. The serration of the lateral margins of the pronotum is still coarser than in *pictus* and the 2nd and 4th teeth of the front tibia are blunter. The female will no doubt be found to resemble closely that of the Indian species, which has also small bare terminal spiracles, differing conspicuously from those of another species from Indo-China taken by the same collector and described below.

Charitovalgus bufo sp. n.

♀. Black, with the scutellum and adjacent part of the elytra brown and the middle and hind femora and tibiae pale, the lower surface rather closely clothed with short white scales. The head, pronotum, except the basal part, a gently curving transverse bar crossing both elytra about the middle but not reaching the sides, and a patch on each side of the propygidium covering the prominent terminal spiracles, bear similar white scales.

Long and narrow, with stout legs. Clypeus not distinctly emarginate. Pronotum longer than its width at the base, with deep median groove and lateral impressions, the groove bordered by strongly elevated carinae extending beyond the middle, the sides converging in front, the front angles acute, the base rounded and preceded by four elevated tubercles. Scutellum long and narrow. Terminal spiracles long and stout. Pygidium flat, the caudal spine curved at the end and minutely 3-dentate. 5th sternite excised in the middle, 6th shining, rugulose, without scales. Front tibia armed with three very small widely separated teeth, middle and hind tibiae very thick, not distinctly toothed, tarsi long, the basal segment of hind tarsus more than twice as long as the succeeding joint and not much shorter than the tibia.

Length 7 mm.

Indo-China: Tavieng, Laos (*R. Vitalis de Salvaza*).

One specimen. This shows an evident relationship to the genotype, *C. pulcher* Kraatz, in its coloration, the great development of the terminal spiracles and the white-scaled hind legs, but it is very different in the massiveness of all the legs, of which the tibiae especially are very thick and the tarsi (in the female) exceptionally long. It is also a considerably larger insect but the caudal spine is relatively a little shorter. As in *C. pulcher*, this is curved downwards at the end and has a lateral tooth on each side of the tip. The thick legs and scaly conical terminal spiracles show that the unknown male is quite unlike those of the group to which the last species belongs.

Charitovalgus scorpio sp. n.

♀. Chocolate-brown, the upper surface clothed rather closely, except at the sides, with black scales and decorated with irregularly distributed white scales, including a cluster near each front angle of the pronotum, one near the middle of each side, an obliquely placed bar near the middle of each elytron and a well-defined spot on each side of the propygidium, reaching but not including the terminal spiracles. The lower surface is black with scattered pale scales.

Long and narrow, with slender legs. Clypeus scarcely emarginate in front. Pronotum slightly longer than it is wide, with two fairly strong parallel carinae in front, not reaching the middle, the sides gently curved and convergent in front and parallel behind, the base rounded. Scutellum rather long and narrow. Terminal spiracles strong, smooth and shining. Pygidium not long, densely punctured and clothed with dark scales, the caudal spine compressed at the end, very sharp and bearing four teeth before the tip, the last sternite almost bare. Front tibia rather narrow, with five lateral teeth. Basal segment of hind tarsus twice as long as the succeeding joint.

Length 4·5 mm.

Eastern New Guinea: Kokoda, 1200 ft., August (*Miss L. E. Cheesman*).

A single female. A male specimen, taken by Miss Cheesman at Diene, at 2000 ft. in November, in all probability belongs to this species in spite of its very different coloration. It is of elongate shape, with more slender legs, brown in colour and densely clothed, above and beneath, with mottled brown, buff and nearly white scales, the pronotum having at the base a large dark median patch and a small spot on each side, the elytra each with an oblique white mark in the middle, the propygidium a dark median triangular spot and the pygidium two similar spots. There are no dorsal tufts but the pronotum bears two slight carinae in front.

Only a single species of Valginae has been described from New Guinea to the present time, viz., *Valgus keysseri* Hauser. Its single known representative is evidently a female, from the mention of the " sting " (stachel), which, like the caudal appendage of *C. scorpio*, bears four teeth beneath. The description (1904, *Deuts. ent. Ztg.* : 40) shows it to be a much larger insect than *C. scorpio* and quite unlike it, with scale-tufts upon the pygidium and propygidium, but no doubt a related species of the same genus.

It is of some interest to find that the Papuan Valginae may be regarded as stragglers of the Indo-Malayan group, showing no relationship with the Australian genus *Microvalgus*.

Genus *Acanthovalgus* Kraatz.

Only males of this genus, remarkable for the spinose hind angles of the thorax, as also of the nearly related *Hoplitovalgus* Kolbe, have been made known as yet. The species here added is described from one male specimen and two females. In the latter sex there is no caudal spine but the end of the pygidium, produced in the male, is rather more narrowly produced in the female. The tarsi are much shorter than those of the male and the front tibiae bear only two rather feeble teeth.

Acanthovalgus peninsularis sp. n.

Black, the sides of the propygidium and pygidium blood-red in the male, the upper surface clothed with chiefly yellowish scales, absent upon the spiniform hind angles of the pronotum and, in the male, from the sides of the propygidium and pygidium, the lower surface black and shining, with patches of pale scales at the sides of the sternum and abdomen.

Body stout and legs rather slender. Head broad, closely punctured, shining in front, closely scaly behind. Pronotum rugose, as broad as long, narrowed in front, bearing two parallel raised lines, not sharply defined, followed by a pair of tubercles before the base, which is strongly rounded. Elytra depressed, closely scaly. Pygidium produced into a lobe, flat beneath and notched at the end.

♂. The elytra are clothed anteriorly with yellow scales and upon the hinder half with grey ones, a narrow band of black scales interposed. The red sides of the propygidium and pygidium are bare, these are black in the middle, the propygidium has a narrow median line and the pygidium a large apical patch of nearly white scales. The propygidium is broad, with the terminal spiracles widely separated and with two black scale-tufts at the hind margin, and the pygidium is vertical with the tip horizontally produced. The front tibia has 3 sharp teeth near the end, the 4th is wanting and the 5th minute. The middle and hind tarsi are long.

♀. More elongate, the propygidium and pygidium sloping, black and clothed densely with yellowish scales, the terminal spiracles less widely separated than in the male, the produced end of the pygidium narrower, feebly notched. Front tibia bearing two short and blunt teeth at the end. Middle and hind tarsi short.

Length 8·5 mm.

Malay Peninsula: Pahang, Cameron's Highlands, 5000 ft., May, June (*H. M. Pendlebury*). A male and two females.

Although the scale-pattern of the males is almost identical, this species is easily distinguished from *A. furcifer* Westw., described from a Sumatran specimen but also taken both in Sarawak (*G. E. Bryant*) and Penang (*Lamb*), by the very feebly notched terminal lobe of the pygidium, contrasted with the acutely forked extremity of *A. furcifer*, as well as by the differently toothed front tibia. Similar differences distinguish it from the North Bornean *A. marquardti* Kraatz, which may prove to be identical with *A. furcifer*.

Genus *Euryvalgus* Moser.

Although the following species differs in important features from the two already described and, like it, inhabits Borneo, I consider it undesirable to add to the number of genera, as the probably great increase in the future in the number of known species is likely to show that there are already too many.

Females of this genus are not yet known.

Euryvalgus tridens sp. n.

♂. Black, clothed, not very densely, with black, brown and yellow scales, absent in the region of the hind angles of the pronotum, the lower surface more uniformly clothed with greyish scales. Large, moderately elongate, with the tarsi long. Clypeus rather shining, its front margin straight. Pronotum much shorter than it is long, rugose in front, striolate behind, with the lateral margins strongly contracted in front, rounded in the middle, deeply excised before the base, with the hind angles blunt. Upper surface lightly grooved longitudinally behind, where there are three pairs of scale-tufts, the 2nd pair wide apart and the 1st and 3rd close together. Base rounded, rather deeply excavated on each side, with a large tufted prominence between the excavations, partly covering the scutellum, which is depressed and narrow. Elytra rugulose, with deep striae near the base alone. Propygidium without scale-tufts but with strongly produced terminal spiracles. Pygidium produced into a short lobe at the end. Front tibia sharply tridentate, middle and hind tibiae short and broad, with slender base. Basal segment of hind tarsus rather shorter than the three succeeding joints together.

Length 9 mm.

Borneo: Sarawak, Quop, April (*G. E. Bryant*). A single male was caught on the wing.

E. tridens agrees in its main features with the genotype, *E. borneensis* Moser, but the front tibiae are tridentate, owing to the complete disappearance of the small intermediate teeth, the short pronotum has a deep excision on each side before the base, the hind angles are not sharp but very blunt, there is a strong median prominence, bearing a large tuft of scales, at the base and the strong tufts borne by the propygidium of *E. borneensis* are absent. The general shape is less short and compact than in that species.

Genus *Dasyvalgus* Kolbe.

This is the predominant genus of Valginae. Although restricted to the Indo-Malayan region, the number of species known is already large and will probably be ultimately very large. Few were known to Kolbe and it is therefore not surprising that features which appeared to justify the separation of various new genera are now seen not to have the importance he attached to them. Six such genera were based by him each upon one species and most of them upon examples of one sex. In his genera *Anepsiovalgus*, *Nannovalgus* and *Spilovalgus* the absence of scale-tufts upon the propygidium is an important distinctive feature. The later-described *Dasyvalgus biplagiatus* Moser, closely related to the genotype of *Spilovalgus*, has such tufts in the male but not in the female, which sex is unknown in most species. The other characters assigned to *Anepsiovalgus*, as already mentioned, appear to me to be only indications of the female sex. The small size and occasional absence of a 5th tooth in the front tibia of *Nannovalgus*, its only other characters, are obviously insufficient to justify it and these three genera appear to me inseparable from *Dasyvalgus*. The very prominent terminal spiracles and produced pygidium, which led to the separation of *Plocovalgus*, are found in progressively diminishing degrees in other species related to *P. waterstradti* and that name must also, in my opinion, be abandoned. *Syngonovalgus* is distinguished almost entirely by the want of sharpness in the two longitudinal ridges upon the pronotum, but these are now found to exist in so many different conditions that the retention of the name would involve the creation of yet other genera of doubtful value. I therefore regard these five names as synonyms of *Dasyvalgus*.

One other genus, *Nipponovalgus*, has recently been separated from *Dasyvalgus* by Mr. Sawada (1941, *Nippon no Kochu* **4** : 3), on account of the number of teeth upon the front tibiae. He has referred to it two species with little resemblance to one another, the Japanese *angusticollis* Wat. and *yonakuniensis* Sawada. I have described here an Indo-Chinese species *Hybovalgus sexdentatus*, the front tibiae of which are toothed in the same way as represented in the excellent figure of *N. yonakuniensis* (Mr. Sawada counts as a 7th tooth the basal prominence of the tibia), which figure suggests to me the probability of a nearer affinity to *Hybovalgus* than to the other Japanese insect. Although five tibial teeth is the normal number in most Valgine genera, it is subject to such altogether unusual variation that the occurrence of one or two supplementary teeth is of very doubtful generic importance.

One of the most constant features of *Dasyvalgus* is the peculiar sinuation of the inner elytral striae, the 2nd interval being always dilated in the anterior part. Although the striation is occasionally effaced upon much of the surface, this peculiarity can always be traced in front.

As no genotype has been assigned to *Dasyvalgus* the common wide-ranging *D. sellatus* Kraatz is here designated genotype. *Valgus laliganti* Fairm. and

D. formosanus Moser are in my opinion synonyms of it. Whether *D. vethi* Rits., an older name, belongs to this species has not been established.

The habit of these little beetles of frequenting the blossoms of forest trees is a sufficient reason why until recent times they have been little known.

Dasyvalgus polychrous sp. n.

Black, with the prothorax and sometimes the sides of the propygidium deep blood-red, the pronotum, propygidium and lower surface bearing rather scattered yellow scales, the elytra decorated with similar but closer scales, forming a broad basal and narrow apical band, united by a narrow sutural band. There is also an intermediate band of white scales and a nearly round spot, composed of black scales, between the last and the basal band; the pygidium closely clothed with yellow scales, the propygidium bearing two large black scale-tufts.

Body short with slender legs. Clypeus punctured, shining, feebly emarginate. Pronotum as long as it is wide at the base, bearing two non-acute parallel ridges extending past the middle, and four elevated black-tufted tubercles before the base, the sides converging in front and nearly parallel behind. Scutellum not very narrow. Elytra closely rugulose. Pygidium feebly produced, with a small flat ventral surface. Front tibia bearing three sharp teeth in the anterior half, the 4th and 5th teeth feeble. Tarsi slender, the basal segment of hind tarsus twice as long as the succeeding joint.

Length 5·5–6·5 mm.

Borneo: Sarawak, Mt. Matang, 1000 ft., Nov. (*G. E. Bryant*); May (*C. J. Brooks*). Six male specimens.

Found in blossoms of *Vernonia arborea*.

By its non-acute thoracic carinae this belongs to the genus *Syngonovalgus* of Kolbe, although it shows no resemblance in other respects to the type of the genus. Like *D. eucharis* Kolbe, it is black with the prothorax deep red and with slender tarsi, the hind feet having a long basal joint. The front tibia has three equal sharp teeth, the upper ones having almost disappeared. The smooth 6th ventral sternite may be concealed by the 5th, but the pygidium always presents a small flat surface behind it.

Dasyvalgus rufipennis sp. n.

♂. Black, with the elytra red and rather closely clothed with yellow scales, smaller and less numerous at the sides, a white patch of scales immediately adjacent to the scutellum on each side and a nearly round black patch close behind the white one; the vertex and pronotum clothed with dark scales and the lower surface and pygidium with pale yellow or nearly white ones, which also form a small spot at the hind margin of the propygidium.

Rather elongate, the clypeus shining, strongly punctured and bilobed, the pronotum longer than wide, with the sides gently curved, converging in front, parallel behind, the anterior half of the surface bearing a pair of sharp parallel ridges, the posterior half with four slight scale-tufts. Elytra closely reticulate, the striae obliterated upon most of the surface and only traceable near the base. Propygidium with well-developed terminal spiracles and slightly developed marginal scale-tufts. Pygidium not produced but with a narrow ventral surface, the 6th sternite smooth and shining. Front tibia bearing three sharp and two blunt teeth. Hind femora closely clothed with pale scales. Middle and hind tarsi rather broad, the basal segment of hind tarsus 1½ times as long as the succeeding joint.

Length 6 mm.

Borneo : Sarawak, Mt. Matang, 1000 ft., Nov. (*G. E. Bryant*).

Seven male specimens were found in blossoms of *Vernonia arborea*.

By its large size, the peculiar scale-pattern and the flat ventral surface of the pygidium this shows relationship to *Dasyvalgus waterstradti* Kolbe. It will be easily recognised by the red elytra clothed with yellow scales, with white and black spots near the scutellum, as well as by the narrow pronotum and the absence of well-developed scale-tufts on pronotum, elytra or propygidium.

Two examples of a variety from S.E. Borneo have the scales of the pronotum yellow.

Dasyvalgus tessellatus sp. n.

Reddish-chestnut colour, with the legs and lower surface darker and decorated with yellow and black scales, the latter confined to two transverse rows of small black spots crossing the elytra before and behind the middle and each composed of four spots of rather rectangular shape. Before, between and behind these two rows are rows of rather similar spots composed of yellow scales. The head, pronotum, propygidium and pygidium are fairly closely clothed with yellow scales and the metasternum and abdomen are shining and bear rather scattered scales.

Not very broad in shape, the clypeus feebly bilobed, the pronotum strongly contracted in front and slightly behind, bearing two not strongly or sharply elevated ridges in front, two tufted elevations in the middle and four before the base, which is rather narrowly lobed in the middle. Scutellum acutely pointed but moderately broad. Elytra not wider conjointly than they are long, the shoulders and apical calli bearing small scale-tufts. Propygidium bearing two yellow scale-tufts rather far apart, the terminal spiracles not sharply elevated. Abdomen coarsely annularly punctured, the 5th sternite slightly emarginate behind, the 6th smooth and shining. Front tibia armed with five sharp teeth, the three terminal ones long. Basal segment of hind tarsus twice as long as the succeeding joint.

Length 7 mm.

Malay Peninsula : Pahang, Cameron's Highlands, 5000 ft., May (*H. M. Pendlebury*).

A single male specimen.

Although belonging, according to the definition, to Kolbe's genus *Syngonovalgus*, this species seems to show a nearer relationship to the typical species of *Dasyvalgus* than to that of *Syngonovalgus*. The colour and scale-pattern are very like those of *D. sellatus* Kr. but it is much larger and the tessellated effect produced by the black and yellow scales upon the elytra is more distinct and uniform. The thoracic ridges are not sharp and the scale-tufts upon the thorax and propygidium are smaller.

Dasyvalgus coriaceus sp. n.

♂. Reddish-yellow, with the metasternum usually black, rather thinly clothed with small pale yellow scales but with a small roundish patch of black scales near the middle of each elytron.

Short and broad, with slender legs. Clypeus strongly punctured, feebly emarginate in front. Pronotum rugulose, rather flat, with a slight semicircular ridge in front and four tufted elevations before the base, the sides rounded and converging. Scutellum moderately broad. Elytra rugulose, with slight scale-tufts upon the shoulders and apical calli. Propygidium, pygidium, abdomen and metasternum densely covered with large annular punctures and evenly clothed with small scales, the propygidium with two small scale-tufts at the hind margin, the pygidium with a short ventral surface, the 6th sternite

smooth. Front tibia armed with three sharp terminal teeth and two very blunt upper ones. Basal segment of hind tarsus not quite twice the length of the succeeding joint.

Length 5·5–6·5 mm.

Malay Peninsula: Pahang, Gunong Tahan, 5550 ft., Dec. (*H. M. Pendlebury*, Type); Perak Mountains (*W. Doherty*). Several male specimens.

In this species the two thoracic ridges, which are so constant a feature of most of the Valginae, are represented only by an almost semicircular elevation at the anterior end of the pronotum. The ridges are not replaced by the blunt raised margins of a median groove as in *D. subnitidus* Kolbe, the type of *Syngonovalgus*, but the groove has disappeared as well as all but the anterior part of the ridges. The scale-tufts upon the pronotum, elytra and propygidium are not conspicuous. All the scales are pale yellow with the exception of those forming a black spot upon each elytron.

Dasyvalgus ruficauda sp. n.

Black, with the hinder part of the abdomen red above and beneath, the pronotum, elytra and sides of the metasternum closely strigose, the head, middle of the metasternum and the abdomen densely punctured, the punctures of the abdomen large and annular. Body not very broad, legs slender, upper and lower surface almost bare of scales but with two tufts of black scales in the middle of the pronotum, four before its base, one on each shoulder of the elytra, two small patches placed transversely before the middle of each and two tufts far apart at the hind margin of the propygidium. Clypeus excised in front, pronotum as long as it is wide, with two sharp parallel ridges extending past the middle, the sides contracted in front, rounded behind, the hind angles very blunt and the base lobed in the middle. Scutellum not very narrow. Elytra short. Terminal spiracles sharply produced. 6th sternite smooth and shining. Pygidium with small ventral surface. Front tibia bearing four sharp teeth, the uppermost preceded by a broadly rounded edge. Basal segment of hind tarsus twice as long as the succeeding joint.

Length 7–8 mm.

Malay Peninsula: Kedah Peak, 3950 ft., March (*H. M. Pendlebury*).

Two male examples. This species is peculiar for the slight development of scales and their total absence from the lower surface. It evidently resembles closely the Bornean *D. nigerrimus* Moser, from which it differs in the conspicuous red colour of the posterior part of the abdomen, including the propygidium, pygidium and the last two sternites, in the thoracic ridges being quite sharp-edged and the front tibia having only four teeth, with a rounded ridge to represent the penultimate one, and in the absence of a second scale-patch upon the elytra behind the first, having instead a small patch upon its outer side. There is a considerable resemblance to *D. eucharis* Kolbe, also found in the Malay Peninsula, but in that the pronotum is red, with blunt thoracic ridges, the upper surface has exiguous white scale-patches, the abdomen is not entirely bare and is distinctly lobed behind. In *D. ruficauda* the pygidium has only a very narrow ventral surface.

Genus *Hybovalgus* Kolbe.

This genus was distinguished from its allies by Kolbe primarily on account of a minute tubercle found at the junction of the mesosternum and metasternum and secondarily by the narrowness of the thorax and the absence from it and the elytra of scale-tufts. The last point was contradicted by himself in the description of his only species, *H. bioculatus*. The apparent

narrowness of the thorax is chiefly due to the relative width of the elytra and has no value for separating the genus from *Dasyvalgus*. Moser, who has added half a dozen related species to the genus, has pointed out that the little sternal tubercle is not always to be found in them. The genus then cannot be regarded as at present well established, but a little more can be added in its justification, viz., the very dense scaly clothing of the abdomen, the existence of scales upon the 6th sternite, indicating that this is not liable, as in *Dasyvalgus*, to be retracted behind the 5th, and the presence of long scales at the hinder edge of the middle and hind femora, where they form fringes or tufts.

Of the seven described species of *Hybovalgus* four inhabit Tonkin, two Yunnan and one Formosa. One now added from North China considerably extends its known range.

Hybovalgus laticollis sp. n.

Reddish-brown, with the propygidium, pygidium and lower surface densely covered with almost white scales, and the pronotum and elytra decorated with nearly white and nearly black scales. Head bearing a pair of brown scale-tufts between the eyes, pronotum with a pair of dark tufts in the middle, an anterior one on each side and four before the base. The shoulders and apices of the elytra carry pale tufts and the propygidium and pygidium have each another pair at the hind margin. The scutellum and the adjoining region of the elytra are densely clothed with pale scales, with an enclosed black spot on each side, and the posterior half of each elytron bears an irregular black patch almost surrounded by white scales.

Upper surface closely rugose, the clypeus rugosely punctured, bilobed, the pronotum a little wider at the base than it is long, with the sides and base rounded and the hind angles well marked. Front tibia armed with five sharp teeth. Hind metatarsus as long as the two succeeding joints.

Length 7·5 mm.

North China : Wei-hai-wei, April (*T. Bainbrigge Fletcher*).

One specimen in the British Museum was found upon oak at Wei-hai-wei in 1899. Another specimen taken by Robert Fortune at a much earlier date is probably from the Shanghai district.

There is a close resemblance between this northern form and *H. yunnanus* Moser, from which it differs by the more roughly punctured clypeus, the broad pronotum, distinctly wider at the base than its length, its more rounded sides and the darker colour of the scale-tufts upon its surface. The pattern formed by the scales upon the elytra is almost the same. The terminal spiracles are a little more prominent.

Hybovalgus sex-dentatus sp. n.

Black, the propygidium, pygidium and lower surface densely covered with yellow scales, except at the sides of the abdomen and parts of the 5th and 6th sternites, the pronotum and elytra decorated with white, yellow and dark brown scales. The scutellum and adjoining region of the elytra are covered with whitish scales, a white decumbent X-shaped mark crosses the two elytra near the middle and there are two irregular patches of dark scales upon each.

Body a little elongate. Head densely punctured, the clypeus bare and bilobed. Pronotum distinctly longer than it is wide, the surface reticulate-punctate, with nearly parallel ridges extending past the middle and bearing a pair of dark scale-tufts before the end. There are four more tufts before the base. Sides rounded, strongly contracted in front

and a little behind, the base rounded and hind angles not distinct. Elytra rugulose, with pale scale-tufts at the shoulders and apices. Propygidium with large scale-tufts and slightly prominent terminal spiracles. Pygidium tufted at the apex. Front tibia armed with three sharp teeth and two very small ones between those and the blunt uppermost tooth. Middle and hind tibiae short and broad, the outer edge bearing a very strong tooth. Basal segment of hind tarsus as long as the two succeeding joints.

Length 7–8·5 mm.

INDO-CHINA: Laos, Ban Naban, Xieng Quang, March (*R. Vitalis de Salvaza*).

The three specimens of this distinct form have the thorax partly abraded. It is more elongate than any other *Hybovalgus* known to me and appears to be the only one of which the front tibiae bear six teeth, the wide interval between the third tooth and the last being occupied by two very small ones. The pronotum is rather ovate in shape, distinctly elongate and contracted behind as well as in front. The two sharp dorsal ridges curve gently outwards, each bearing a tufted tubercle towards the end. These and the four tufts before the base are rather inconspicuous. The mesosternal prominence is scarcely traceable.

Mimovalgus gen. n.

Rather long and narrow, with stout legs, the femora long and slender, the tibiae broad, the middle and hind tibiae very short, the tarsi broad, flat and densely hairy. Head not long, the clypeus rounded at the front margin, the maxillae with long extruded brushes. Pronotum without scale-tufts but with two parallel ridges upon the anterior half. Elytra not tufted, together much wider than the pronotum but longer than their combined width, each bearing six straight and nearly equidistant striae upon the dorsal part. Propygidium long and parallel-sided, with its hind angles produced backwards and bearing the terminal spiracles, the hind margin without scale-tufts. Pygidium broad, nearly vertical, truncate at the tip and without ventral surface. Front tibia armed with five sharp teeth.

Genotype: *Mimovalgus rufus* sp. n.

The remarkable insect for which this genus is proposed has no resemblance to any other known species of VALGINAE and, although its relationship to *Dasyvalgus* is fairly close, in the absence of any connecting links it appears more natural to separate than to unite them. It differs by its broadly flattened and hairy tarsi, its peculiar elongate shape, abruptly truncated behind and terminated by the very prominent last pair of spiracles, which occupy the angle formed by the union of tergite and sternite and are separated by the entire breadth of the body, by the complete absence of scale-tufts from the upper surface and by the quite different and perhaps primitive parallel striation of the elytra.

Some of these peculiarities can be explained as due to mimicry. The insect, of which only a single specimen is known, is one of the LYCIDAE-imitating forms found amongst flower-frequenting insects in so many different groups. It has the very conspicuous red colour, with black head, legs and hinder margin, as well as an imitation of the longitudinally ribbed elytral surface, which characterise many Oriental LYCIDAE.

Mimovalgus rufus sp. n.

Dull black, the whole surface strongly and closely punctured, the body closely clothed above and beneath with nearly round decumbent scales, replaced upon the clypeus and

parts of the legs by short setae. The scales are black or very dark except upon the pronotum and scutellum, where they are bright ochreous red, except for a small patch of dark ones on each side of the base of the pronotum, and upon the elytra, where narrow, straight, longitudinal lines of red and dark scales alternate, forming six red lines separated by five dark ones, the extreme hind margin wholly dark. Clypeus not excised at the front margin. Pronotum almost parallel-sided behind and narrowed in front, bearing a pair of sharp parallel ridges, united in front and extending past the middle behind. Scutellum long and narrow. Elytra flat above, moderately broad, parallel-sided, with straight parallel striae, the alternate intervals bearing rows of red scales, the 4th row from the suture narrower than the rest, the red scales gradually giving place to dark ones towards the extremity. Propygidium very broad and parallel-sided, as wide at the extremity as the elytra at the shoulders, the produced angles carrying the spiracles very stout, the hind margin entirely without tufts.

Length 7 mm.

Malay Peninsula: Penang.

The only known specimen of the species was taken many years ago by Lamb and reached the British Museum with the Bowring collection in 1863. It is almost certainly a male.

Genus *Xenoreoderus* Arrow.

In *The Fauna of British India—Cetoniinae*, I referred to this genus the Malayan *Valgus pygmaeus* G. & P., as to which the only description of any value is that of Schaum to which I referred. Since the publication of my volume another genus, *Lepivalgus*, has been formulated by Moser and to this, which differs from *Xenoreoderus* by the long basal segment of the hind tarsus, this species should be transferred.

Xenoreoderus nanus sp. n.

Reddish-chestnut colour, clothed with pale yellow or white oval scales, closely packed upon the propygidium, pygidium and sides of the body beneath, fairly close upon the sutural margins of the elytra and especially near the scutellum and the posterior angles, scattered upon the pronotum and the outer half of the elytra.

Body moderately broad, with slender legs. Clypeus bare, its front margin rounded and feebly emarginate. Maxillary brush moderately long. Pronotum a little longer than wide, roughly punctured and bearing two rather ill-defined longitudinal elevations, nearly equidistant from each other and from the sides, the front angles blunt, the lateral margins serrated in front, feebly diverging behind and continuous with the rounded base, hind angles wanting. Scutellum fairly large, not narrow. Elytra roughly punctured, slightly shining. Propygidium bearing two small, widely separated scale-tufts at the hind margin, the terminal spiracles not elevated. Basal segment of hind tarsus not longer than the succeeding joints.

Length 4 mm.

Burma: Yedashe, March.

Six specimens, apparently males, were taken in flowers.

This is the smallest species of *Xenoreoderus* at present known. It has almost the same shape as *X. humilis* Gestro and *occidentalis* Arrow, but the clypeus is broader in front and a little notched in the middle, the longitudinal ridges upon the pronotum are more pronounced and it bears no distinct scale-tufts, the scales are differently arranged upon the elytra and the terminal spiracles upon the propygidium are not elevated.

Genus *Oreoderus* Burmeister.

Although it has been known for more than a century, the genus *Oreoderus* is still represented by species from India and Burma only, a Malayan form attributed to it, *O. pilosulus* Rits., having been removed by Moser to his genus *Chaetovalgus*. The species now appear to be rather numerous but without indicating any considerable extension of its geographical range. The genotype, *O. argillaceus* Hope, as well as a representative of the closely related genus *Podovalgus*, have been recorded by Wasmann as inhabitants of Termite-nests. It is probable that *O. latipes* and *crassipes*, here described, have similar habits and not improbable that this will be found the case with all species of the genus.

A peculiar feature of the South Indian *Oreoderus gravis* Arrow, not yet mentioned, is a small median process at the front margin of the clypeus. This is blunt in the female but stalked and bifid in the male.

Oreoderus maritimus sp. n.

Black or dark brown, densely clothed with scales, which are grey on the lower surface, and also on the upper surface in the female but chiefly black on that of the male, intermixed with yellow and grey scales upon the pronotum and scutellum and along the base, apex and sutural margins of the elytra, which also show a short oblique line of white scales crossing each in the middle; the propygidium and pygidium of the male clothed with grey scales, each with a large patch of erect dark scales on each side.

Moderately broad, with fairly long legs. Clypeus a little narrowed in front, with the front margin rounded. Pronotum very slightly longer than it is wide, with the two median ridges extending a little past the middle and slightly contracted behind and the outer elevations very oblique and fairly long. The lateral margins are serrated and nearly parallel except in front, the hind angles are blunt and the base is rounded. Scutellum moderately broad. Elytra with fine striae, the apical callus rather prominent. Propygidium notched in the middle of the hind margin. Middle and hind tibiae strongly toothed at the middle of the outer margin, the middle tibiae produced at the end, the hind tibiae dilated. The joints of the hind tarsus, except the last, are almost equal in length, the basal joint broadly triangular.

♂. Pygidium a little impressed longitudinally, rounded at the end.

♀. Apical callus of the elytra tufted, pygidium pointed at the end and a little reflexed.

Length 8·5–10 mm.

Burma : Rangoon, July (*L. Fea*). One specimen.

Malay Peninsula, West Coast : Langkawi I., near Penang, April, May (*H. M. Pendlebury*). Seven specimens, including the type.

O. maritimus is one of the largest species of the genus so far known. Like the largest, *O. gravis* Arrow, it has a slight prominence before the extremity of each elytron, which, in the female, bears a short tuft of setae, and the propygidium has a slight notch at the middle of its hind margin. There is also a longitudinal impression upon the pygidium, found in no other species known to me. There is a rather close resemblance to *O. brevipennis* Gestro, one of the two original specimens of which, a male from the Karen Hills, is in the British Museum. In that sex the new species can be distinguished by the large patch of upstanding dark scales upon each side of the propygidium and pygidium, the slight notch in the former and the longitudinal groove upon the latter. In addition, the pronotum is more gradually narrowed in front and less quadrate. The scales upon the upper surface of the female are larger,

denser and more uniform in colour than those of the male and the last ventral sternite, like the pygidium, is a little produced in the middle behind.

Oreoderus quadricarinatus sp. n.

Black, closely clothed with brown scales above and greyish-white ones beneath, the elytra each bearing a small patch of white scales near the middle, the scales upon the clypeus and at the front margin of the pronotum also pale.

Rather elongate, depressed, with fairly stout legs. Head entirely punctured and scaled, clypeus semicircular in front. Pronotum much longer than wide, narrowed and rounded in front, almost parallel-sided behind, a little dilated at the base, with prominent but blunt hind angles, and bearing in front four sharply elevated ridges, which are strongly curved, the outer ones nearly parallel with and equal in length to the inner and all converging behind, ending abruptly before the middle, where there is a longitudinal depression. The inner ridges enclose an oval area. Elytra short, together about as wide as long. Propygidium rounded behind, the terminal spiracles not distinctly elevated. The 5th sternite twice as long as the 4th. Hind femora thick; middle and hind tibiae each with a stout lateral tooth. Tarsi not long nor dilated, the hind metatarsus triangular, as long as the 2nd joint.

Length 8–9 mm.

Tonkin (*R. Vitalis de Salvaza*): Hat Thoung, Nov. (Type), Pak Neun, Oct., Souvannaphoum, Sept. These specimens apparently males.

The four very sharp and nearly equal carinae upon the anterior half of the pronotum distinguish the species from all others. They are strongly curved, the two on each side almost parallel and all reach the front margin of the thorax, where the inner ones unite. They end abruptly on the verge of a slight median depression. The four posterior tibiae have each a very stout tooth near the middle of the outer edge.

Oreoderus clypealis sp. n.

♂. Black, fairly closely clothed with grey scales, rather paler upon the propygidium, pygidium and lower surface and each elytron decorated with a triangular patch of white scales in the middle, closely preceded and followed by a large area covered by dark brown scales.

Not very elongate, depressed, with rather slender legs. Head densely clothed with scales, the clypeus with its front edge straight and reflexed. Pronotum long and narrow, bearing a pair of short, not strongly elevated ridges, diverging in front, parallel behind and not reaching the middle, and a pair of very short oblique lateral elevations, the base strongly rounded and the hind angles very obtuse. Scutellum long and narrow. Elytra conjointly as long as wide. Propygidium not very long, the terminal spiracles distinctly elevated. The 5th sternite more than twice as long as the 4th, broadly excised behind. Middle and hind tibiae indistinctly toothed at the outer margin. Tarsi not dilated, 1st and 2nd joints of the hind tarsus triangular and equal, the rest longer.

Length 7 mm.

N.E. Burma: Sadon, 3600 ft., July (*R. Malaise*). A single male.

This species may be easily distinguished by the clypeus, of which the front margin is straight and recurved. The pronotum is long and narrow, its median carinae short and feebly elevated and the usually conspicuous anterior loop not prominent. The last pair of spiracles are rather prominent.

Oreoderus latipes sp. n.

Dark brown, densely clothed with grey scales above and beneath. Moderately broad, with rather short legs, the tibiae broad, the tarsi short, with joints of nearly equal length, the 1st, upon the middle and hind tarsi, as broad as it is long. Head closely scaly, the clypeus convex, rounded at the front margin. Pronotum a little longer than broad, with a pair of not very sharp median ridges, converging a little behind and extending to the middle, and a rounded elevation on each side, the lateral margins of the pronotum nearly straight behind and diverging to the base, which is well rounded. Scutellum triangular, not narrow. Propygidium and pygidium densely scaly, the terminal spiracles slightly prominent. 5th sternite emarginate behind and 6th almost as long as the 5th in the middle.

Length 8 mm.

Tonkin : Hoabinh (*A. de Cooman*).

The type is unique.

This species shows an evident approach, in its broad thick legs, to the genus *Podovalgus*, but the tarsi are less closely compacted than in *Podovalgus* and the clypeus is rounded in front instead of being bilobed. *O. latipes*, however, is a very aberrant species. The thoracic ridges are not sharp and, as in *Podovalgus griseus*, instead of oblique outer carinae, there is a rounded elevation on each side. All the tibiae are very broad, the teeth of the front pair very short and stout, the middle and hind pairs without the usual marginal tooth or spine and all clothed externally with very long scales.

Oreoderus crassipes sp. n.

Reddish-brown, moderately closely clothed above and beneath with nearly round ochreous scales, the legs moderately long, the tarsi short and thick.

Body rather narrow, with the clypeus rounded in front, the pronotum a little longer than it is wide, longitudinally depressed in the middle, slightly contracted at the base, the hind angles obtuse. Median ridges very strongly elevated in front, almost parallel, vanishing just before the middle, the lateral elevations short and very oblique. Scutellum triangular, fairly broad. Propygidium rounded behind, the terminal spiracles scarcely elevated. 5th sternite as long as the preceding three together, the 6th a little shorter.

Length 8 mm.

United Provinces, India : Karwapan, Dehra Dun, December.

The type is unique.

Like *O. latipes*, this has rather short, thick tarsi, but the tibiae are not broader than usual and the middle and hind tibiae have each a stout spine at the middle of the outer edge. The shape is narrower than that of *O. latipes*, it is less densely scaly both above and beneath, the pronotum is broadest before and not at the base and the median carinae are shorter, sharper and more parallel. The front tibiae are less broadly toothed, the middle and hind tibiae much narrower and less closely scaly and each has a spine at the outer edge. The tarsal joints, except the last, differ little in length, but the hind metatarsus is as broad as it is long.

Oreoderus suco sp. n.

Brownish-black, clothed with ochreous round or broadly oval scales, paler (sometimes white) and more densely packed upon the pygidium and lower surface and sometimes forming a short pale transverse bar common to both elytra near the middle. The scales are fewer and darker upon the anterior half of the pronotum and the outer part of the elytra.

Short and broad, with slender legs, the clypeus rounded in front, the pronotum longer than wide, bearing two sharp parallel ridges, extending from the front to the middle, and two shorter outer ones almost parallel with them. Lateral margins serrate, nearly straight, diverging from the front almost to the base, the basal margin rounded. Scutellum long, narrow and blunt. Propygidium nearly straight at the hind margin, the terminal spiracles slightly elevated. Metasternum almost devoid of scales in the middle. 5th sternite twice as long as the preceding one. Uppermost tooth of the front tibia blunt and not far removed from the 2nd, the 1st and 2nd more distant and rather sharp. Hind tibia not broad at the end but produced externally, the hind tarsi long and slender, with the basal joint half as long as the next.

Length 4·5 mm.

South India : Sidapur, Coorg, 3000 ft., March to June (*Y. R. Rao*).

The five specimens are probably all males.

Besides being much smaller than any other known *Oreoderus*, this has a shorter and broader form than usual. The legs are slender and the hind tibiae have a peculiar shape. They are not enlarged from base to apex, with a broad straight posterior edge, but a little narrowed behind and produced on the outer side into a rectangular process as long as the 1st tarsal joint and a little dilated and hollowed at the end. The extruded hair-pencil formed by the maxillary bristles is nearly as long as the head, which seems to show that, unlike other species of the genus, its habit is to frequent flowers.

Genus *Microvalgus* Kraatz.

In addition to *Sphinctovalgus*, which I consider should be excluded, Kolbe included in his *Valgidae ordinis antiqui* three genera for African forms and one (*Paediovalgus*) for the sole Oriental species *micros* Kolbe. Of the African genera, *Ischnovalgus* differs from the rest in the small size of its scutellum and *Stenovalgus* and *Synistovalgus* have been treated as one by M. Burgeon, who appears not to have seen the genotype, *Stenovalgus carinulatus* Kolbe. This has front tibiae so different from those of other species that I consider *Stenovalgus* should, for the present at least, remain as a monotypic genus. *Synistovalgus*, containing the majority of the African Microvalgini, and *Paediovalgus*, with its single Oriental species, differ in no important feature from the Australian species of *Microvalgus*. The very trifling details by which Kolbe attempted to differentiate the three genera, viz. the degree of elevation of the thoracic margins in *Synistovalgus* and the size and arrangement of the scales in *Paediovalgus*, fail completely when tested by the larger number of species now known, and it is evident that he was chiefly influenced by geography. He has described the front tibiae of *Synistovalgus* as distinguished by bearing five teeth in the male and three in the female but this, if true of some species, is certainly not of all. Lea has divided the Australian forms into two groups, in one of which the pygidium of the male is produced at the apex, while in the other it is not. The two groups are found also in Africa and the male of the West African *schoutedeni* Moser has its pygidium of the same peculiar form as that of the male Australian *M. mucronatus* Lea. The production of the middle tibia of the male and the modification of its two terminal spurs are also common to all the species. In fact the relationship of these insects is so remarkably close that the proper course seems to me to be to regard them as forming a single widespread genus, which must be called *Microvalgus*. Attention is thereby called to their interesting occurrence in the continents of Australia and Africa, with only a single known species, *M. micros* Kolbe, in

the lands lying between those continents. These minute insects, however, are still little known and the genus will, in all probability, be found elsewhere.

The earliest described form, *Microvalgus lapeyrousei* G. & P., is probably the female of one of the later-described Australian species but only careful comparison of the type (perhaps in the Geneva Museum) with other authentically named specimens can enable it to be identified. Lea has expressed himself unable to distinguish females of *M. bursariae*, *vagans* and other species of the genus, owing in part, no doubt, to the want of the true female forms. Tasmanian females in the British Museum of *M. bursariae*, the only species known in the island, are quite unlike females from Victoria which I received from Lea with that name or those of any other species known to me. Collection of much more numerous specimens must be awaited for a proper study of both sexes of the insects.

M. (*Stenovalgus*) *bifasciatus* Kr. was figured and re-described by Péringuey under the name *Stenovalgus bimaculatus*.

Microvalgus flavipennis sp. n.

♂. Black, with bright yellow elytra, their lateral margins indefinitely darkened, the upper surface bearing very small scattered white scales, those on the elytra in single lines and those on propygidium and pygidium a little larger and closer.

Moderately elongate, the head rugose, the clypeus not notched in front. Pronotum a little longer than wide, bearing close shallow umbilicate punctures, the sides and base rounded, the hind angles obsolete and front angles sharp. Scutellum long and narrow. Elytra shining, rather smooth. Propygidium and pygidium rather shining, the former with the terminal spiracles not very prominent, the latter with the tip strongly triangularly produced and reflexed. Front tibia bearing three small sharp lateral teeth in the anterior half. Lower surface clothed with rather scattered setae, the metasternum hollowed in the middle, the abdomen deeply hollowed, the penultimate sternite with a smooth naked cavity, not sharply carinate at the sides but bearing a curved ridge behind, crowned by a crest of fine erect reddish setae increasing in length from the middle to the sides.

Length 3 mm.

New S. Wales: Sydney, Dec. (*G. E. Bryant*); Jervis Bay, Nov. (*F. A. Rodway*), Type.

Two male specimens, one of them taken by Dr. Rodway from flowers of *Leptospermum scoparium*.

In the shining upper surface and small sparse scales this resembles *M. glaber* Lea, but the brightly coloured elytra distinguish it from that and all other species. It is also peculiar in the toothing of the front tibia and the fringe of hairs, long at each end, which terminates the abdominal cavity. *M. glaber* is described by Lea as having the prothorax about as long as wide and bearing shallow punctures. In specimens from North Queensland in the British Museum, perhaps representing a northern race of *M. glaber*, it is distinctly longer than wide and not punctured but reticulate. The elytra bear rows of very small scales, as in *M. flavipennis*.

Microvalgus longicollis sp. n.

♂. Black, clothed with yellowish scales, except upon the clypeus and the middle of the metasternum and penultimate sternite, the scales of the upper surface small, narrow and partly erect, scattered upon the head, pronotum and sides of the elytra and forming lines of single scales upon the dorsal intervals, those upon the lower surface rather closer, rounder in shape. Head strongly punctured, clypeus emarginate in front. Pronotum

much longer than wide, finely reticulate, depressed on each side behind the middle and deeply grooved along the middle of the posterior half, the sides nearly straight, diverging from the front angles, which are produced, to the obtuse hind angles, the base strongly rounded. Scutellum long and narrow. Elytra as long conjointly as wide, moderately shining, bearing longitudinal series of large shallow punctures. Terminal spiracles very prominent. Pygidium vertical, not produced at the apex. Front tibia bearing only three distinct teeth, the middle one very blunt. Tarsi very long. Metasternum deeply excavated in the middle, abdomen very short, arched, the penultimate sternite smooth and shining in the middle.

Length 3·5 mm.

Belgian Congo : Ituri (*L. Burgeon*).

A single male specimen was acquired by the British Museum with the Bourgoin collection. It bears considerable resemblance to *M. luluensis* Burg. and is of similar size and shape, with a similar clothing of scales, those of the elytra arranged in single lines, but the scales of the new species are larger and more numerous and there is an additional yellowish matter clothing the propygidium, pygidium and sides of the body beneath. The pronotum is longer, narrower in front, with straighter sides, and strongly grooved in the middle behind. The scutellum is narrower. The terminal spiracles, as in *M. luluensis*, are very prominent.

Microvalgus reticulatus sp. n.

♂. Black, with a clothing of whitish scales, arranged in lines of single scales upon the dorsal intervals of the elytra, close upon the scutellum, rather scattered upon the head, pronotum, propygidium, pygidium and sides of the elytra and larger and more closely set upon the sides of the body beneath. Head rugose, the clypeus scarcely emarginate in front. Pronotum longer than wide, with shallow reticulate sculpture, the sides nearly straight in front, rounded behind and continuous with the strongly rounded base. Scutellum rather wide at the base. Elytra as wide conjointly as they are long, bearing longitudinal series of large shallow punctures. Terminal spiracles very sharp and prominent. Pygidium vertical, not produced at the apex. Front tibia armed with five teeth, very blunt and feeble except the terminal one. Metasternum deeply hollowed in the middle, abdomen very short, arched, the penultimate sternite closely punctured in the middle.

Length 3 mm.

Gold Coast : Aburi (*W. H. Patterson*).

Three male specimens were taken. This minute insect resembles *M. longicollis* and the scales upon its upper surface are similarly arranged, but it is smaller, the tarsi are less slender, the pronotum less elongate, without median groove or well-marked lateral impressions, the sides almost straight in front but meeting the base in a broad curve and without hind angles. The terminal spiracles are still more produced. The front tibiae are quite differently toothed.

SPOLIA MENTAWIENSIA: RHOPALOCERA, LYCAENIDAE AND RIODINIDAE

By N. D. Riley, F.Z.S., F.R.E.S.

British Museum (Natural History).

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(Read 5 April 1944.)

With Two Plates.

The material of which an account is given below reached me through the late Lord Rothschild in October, 1926. It was not possible to deal with it then, but in 1930 and 1931 all had been finished, except the genus *Jamides*, and descriptions of the many new forms written. Since 1931 other duties have rendered further progress difficult; indeed, but for the fact that in 1939 Dr. A. S. Corbet undertook to revise my notes and prepare the MSS. for press, this would still have remained unavailable. I take this opportunity of thanking Dr. Corbet for his very great assistance. His special knowledge of the Malaysian butterflies, and particularly of the advances in our knowledge of them which have been made during the last decade (to which he has himself very largely contributed), has been invaluable in bringing up-to-date my notes of ten years ago. In particular I have to thank him for dealing with the genus *Jamides*, in respect of which, incidentally, we had arrived independently at almost identical conclusions (see Riley & Corbet, 1938, *Trans. R. ent. Soc. Lond.* **87** : 147) and for revising my account of the genera *Nacaduba*, *Curetis* and *Marmessus*.

Four species of Riodinidae and 52 Lycaenidae are recorded, variously distributed between the islands of Siberut, Sipora and N. Pagi, the actual number from each island being 36, 35 and 16 respectively. From the Batu Islands (Pulau Tello), three are recorded. Of these species, 27 are represented by new subspecies which are described, and four by specimens which, though apparently representing new subspecies, are in such poor condition as to render description unjustifiable. Opportunity has also been taken to describe several other new subspecies from neighbouring parts of the Malaysian region, notably Sumatra, when these have come to light in the course of work.

It is clear from the foregoing figures that the Riodinidae and Lycaenidae of the Mentawi islands show a very marked amount of specialisation. In the Riodinidae all four species are represented by well-defined subspecies; in the Lycaenidae the amount of specialisation is probably even greater than at first sight appears since in many instances, in which specimens have been referred to the subspecies inhabiting neighbouring islands (or the mainland of Sumatra), the material available has been very deficient either in quantity or quality. When ample material was to hand, as in the genera *Marmessus* and *Eooxylides*, it was at once apparent that each island had its own characteristic subspecies.

No attempt has been made to assess the affinities of these Mentawi races. The impression is that, on the whole, they depart from their Sumatran counter-

parts in the same general direction as those of, for example, Nias, but in varying ways. In that sense their affinities may be called Paramalayan; but in as much as the obvious centre of distribution to all these islands is Sumatra, their closest affinities clearly lie there. Melanism of the underside is very prominent, particularly in the RIODINIDAE and in the Lycaenid genera *Castalius*, *Pithecops*, *Megisba*, *Euchrysops*, *Curetis*, *Eooxylides*, *Rapala* and *Sithon*. In this respect *Marmessus* is interesting in that although the markings of the underside show a marked increase in blackness (as compared with Sumatran races), yet the ground colour is distinctly lighter. Indeed, melanism is perhaps hardly the correct term to use, as the darkening in all the genera is not a general darkening, but principally an increase in the size and depth of the dark markings. Besides *Marmessus*, this is particularly noticeable in the genera *Castalius*, *Pithecops*, *Neopithecops*, and *Megisba*; it would seem that all the species in a certain type of habitat had moved along parallel lines of variation or responded in a similar manner to the action of a common set of factors. In this connection Jordan's reference (1937, *Nov. Zool.* **40**) to the enlarged red spots on the underside of the hind-wings of three out of the four Kite Swallowtails (*Papilio sarpedon*, *doson*, *agamemnon* and *evemon*) present in the Mentawi islands is interesting, and perhaps all the more so when it is pointed out that nearly all the representatives of the Lycaenid genera *Catochrysops*, *Euchrysops*, *Jamides* and *Nacaduba* occurring there are also characterised by an enlargement of the orange (or red) anal spot on the underside of the same wing.

Of so few of the species are more than the main outlines of distribution properly filled in, that any precise faunistic analysis is out of the question. It may, however, safely be said that the species here dealt with fall into several fairly well-marked zoo-geographical groups.

1. Strictly Malaysian species, *Taxila thuisto*, *Allotinus horsfieldi*, *Jamides zebra* and *J. parasaturatus*, *Curetis sperthis* and *C. hera*, *Loxura cassiopeia*, *Eooxylides tharis*—8 species.

2. Malaysian, but extending into but not beyond Burma, *Abisara kausambi*, *Taxila haquinus*, *Cyaniriodes libna*, *Poritia philota*, *Simiskina pharyge*, *Miletus symethus*, *Allotinus taras*, *A. nivalis*, *Jamides cunilda*, *J. cyta*, *Nacaduba kurava*, *N. aluta*, *Amblypodia narada*, *Arhopala aedias*, *A. atosia*, *A. moolaiana*, *A. kounga*, *A. cooperi*, *A. vihara*, *A. alitaeus*, 3 species of *Marmessus*, *Sinthusa nasaka* and *Sithon nedymond*—25 species, only four of which, *J. cyta*, *A. narada*, *N. kurava* and *A. alitaeus*, extend beyond Malaysia eastwards.

3. Indo-Australian species,—All the remainder, 23 species, most of which range from Indo-China to the Papuan subregion.

Of the 56 species listed only 9 had been previously recorded from the Mentawi islands, by Hagen [1]; 25 have been reported from Nias, 4 from Engano, 7 from Simalur, 2 from Batu. It is interesting to note of these species which are recorded from other Paramalayan islands besides Mentawi that, whereas 6 are strictly Malaysian, 9 fall into category 2, and 17 into 3 (as given above) yet all those that have been recorded from the Nicobars fall entirely in the third group of very wide-ranging species. This suggests rather strongly that the Nicobars have little claim to be grouped amongst the Paramalayan islands; not one of the truly Malaysian species occurs there.

Corbet (1942, NYMPHALIDAE) has summarised the distribution of the whole

[1] This assumes that all Hagen's species are represented in the present collection. He was not able to determine three of his species beyond the genus.

of the Rhopalocera recorded from Mentawi. The distribution of all the Mentawi LYCAENIDAE and RIODINIDAE is summarised in the following table. To avoid repetition these particulars are not given in the systematic account of the species, except in respect of the Mentawi islands themselves. The table is based almost exclusively upon material in the British Museum (Natural History).

TABLE 1.

Distribution of RIODINIDAE and LYCAENIDAE recorded from Mentawi.

	Indo-China	Burma	Siam	Malay Peninsula	Sumatra	Java	Borneo	Nicobars	Simalur	Nias	Engano	Mentawi: Pagi	Mentawi: Siberut	Mentawi: Sipora	Batu	Lesser Sunda Is.	Celebes	Papuan Subregion
Zemeros flegyas	×	×	×	×	×	×	×			×			×	×		×	×	
Abisara kausambi		×		×	×	×	×			×				×				
Taxila thuisto				×	×		×						×					
Taxila haquinus		×	×	×	×	×	×					×	×					
Cyaniriodes lilna		×	×	×			×						×					
Poritia philota		×		×	×		×			×			×					
Simiskina pharyge		×		×	×	×	×							×				
Allotinus taras		×		×	×	×	×							×				
Allotinus horsfieldi				×	×	×	×				×			×				
Allotinus nivalis		×		×	×	×	×			×			×	×				
Castalius ethion	×	×	×	×	×	×	×	×	×	×		×	×	×		×	×	
Castalius elna	×	×	×	×	×	×	×	?	?	×	?		×	×	?	×	×	
Pithecops hylax	×	×	×	×	×	×	×			×				×				
Everes lacturnus	×	×	×	×	×	×	×	×					×			×	×	×
Megisba malaya	×	×	×	×	×	×	×	×	×					×		×	×	×
Celastrina puspa	×	×	×	×	×	×	×	×	×	×		×	×	×		×	×	×
Euchrysops pandava	×	×	×	×	×	×		×						×				
Anthene emolus	×	×	×	×	×	×	×		×					×		×	×	×
Catochrysops strabo	×	×	×	×	×	×	×	×	×	×						×	×	×
Catochrysops panormis	×	×	×	×	×	×	×	×					×	×		×	×	×
Jamides celeno	×	×	×	×	×	×	×	×	×	×	×		×	×		×	×	×
Jamides zebra				×			×			×			×	×				
Jamides parasaturatus				×	×	×							×	×				
Jamides alecto	×	×	×	×	×	×	×	×	×	×	×		×	×		×	×	×
Jamides cunilda		×		×	×	×	×						×					
Jamides cyta		×		×	×	×	×							×		×	×	×
Nacaduba pavana	×	×	×	×	×	×	×						×				×	
Nacaduba hermus	×	×	×	×	×	×	×						×			×	×	×
Nacaduba sanaya (Ceylon)	×			×		×	×			×			×				×	
Nacaduba kurava		×		×	×	×	×			×				×		×	×	×
Nacaduba aluta		×		×	×	×	×			×			×					
Curetis bulis	×	×		×	×	×	×			×				×				
Curetis sperthis				×	×	×	×			×			×	×				
Curetis hera				×	×		×			×				×				
Amblypodia narada		×		×	×	×	×			×			×				×	×
Arhopala aedias		×		×	×	×	×			×			×					
Arhopala atosia		×	×	×	×		×					×	×					
Arhopala moolaiana		×	×	×								×	×	×				
Arhopala alitaeus		×		×			×							×			×	
Arhopala kounga		×		×	×		×					×		×				
Arhopala centaurus	×	×	×	×	×	×	×			×		×			×			×
Arhopala cooperi		×		×	×								×					
Arhopala eumolphus	×	×	×	×	×	×	×					×						
Arhopala labuana				×	×		×					×						
Arhopala vihara		×		×	×		×			×		×						
Loxura cassiopeia				×	×		×			×			×	×				
Cheritra freja	×	×	×	×	×	×	×						×					
Marmessus thesmia		×	×	×	×		×					×	×	×				
Marmessus scudderii		×		×	×							×	×	×	×			
Marmessus lisias		×	×	×	×	×	×		×	×		×	×	×	×			
Eooxylides tharis				×	×	×	×		×			×	×	×				
Hypolycaena erylus	×	×	×	×	×	×	×		×				×	×		×	×	×
Rapala dieneces	×	×	×	×	×	×	×			×		×	×	×				
Rapala manea	×	×	×	×	×	×	×				×			×		×	×	
Sinthusa nasaka		×	×	×	×	×	×					×						
Sithon nedymond		×		×	×	×	×						×	×				

No attempt has been made to quote references to the original and other descriptions of the species and subspecies listed in this paper, as these would

be an unnecessary encumbrance to a paper of which the interest is primarily faunistic. Such references can be found in Seitz's *Macrolepidoptera of the World* **9**, but a list of further papers and other works having a direct bearing upon the taxonomy of the species and genera recorded here, and upon their distribution outside the Mentawi Islands, is given below.

The earliest paper on Mentawi Lepidoptera appears to be by B. Hagen (1898, *Entom. Nachr.* **24** : 193–207). It makes no reference, however, to Lycaenidae or Riodinidae.

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Riodinidae.

Zemeros flegyas sipora subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 16 ♂, 7 ♀.
Sipora, 10.x.24 (*H.H.K.*). 1 ♂ (Holotype).
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♀ (Allotype).

Belongs to the *albipunctata* group of subspecies. All the specimens are of pronounced "wet season" type. On the upperside there remains a complete series of very small marginal, and four (♂) or six (♀) submarginal, points, all of which are very sharply defined

and pure white, standing out very prominently against the well-marked black and chocolate general pattern of the upper surface. It is, in particular, the small size and sharp definition of the anterior spots of the submarginal series (sometimes called the subapical spots) that distinguish the subspecies most readily from *albipunctata*, *phyliscus* and *javana*. The female is only very slightly brighter than the male, differing in this respect markedly from the brightly coloured females of the neighbouring subspecies *sparsus* (from Nias), *phyliscus* (from Sumatra) and *hostius* (from Borneo). Superficially *sipora* is nearer to the very rare wet-season form of subsp. *javana* than to any other form.

Abisara kausambi disparilis subsp. n.

Sipora, 31.x.24 (*C.B.K.* and *N.S.*). 1 ♂ Holotype.
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂ Paratype.

Intermediate between *A. kausambi kausambi* Felder and *A. k. niasana* Fruhst. Large; F.W. length 23 mm.; fore-wing with only a very faint subapical paler crescentic patch (absent in *A. k. niasana*) which is not so strongly developed as in typical *kausambi*. Hind-wing with the apical pair of black spots large and prominent as in *A. k. niasana*, the anal pair smaller, but prominent, the two pairs not approximately equal in size as in *A. k. niasana*, but both distinctly more prominent than in any other subspecies.

The subsp. *oenobarus* Toxopeus from Pulau Weh, off the north-west point of Sumatra, is not represented in the British Museum (N.H.).

Abisara savitri susa Hewitson.

Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 7 ♂.

Comparison of the short series of *Abisara savitri* that was contained in the Hewitson collection, with Hewitson's figure of his *Sospita susa*, convinces me that Hewitson's name was based upon a Sumatran example of this species. Fruhstorfer's name, *Abisara savitri tentyra*, for the Sumatran race should be superseded therefore by *A. savitri susa* Hewitson.

Taxila thuisto melanotica subsp. n.

Siberoet, 28.ix.1924, 1 ♀ (Holotype) (*H.H.K.*).
Siberut, Sept. 1924, 1 ♀ (*C.B.K.* and *N.S.*).

This race represents the melanic extreme in *thuisto*, so far as is known at present. Its general features are those of typical Malayan *thuisto*, with which I include Sumatran examples, although Fruhstorfer regarded them as distinct, and described them as subsp. *entyches*; the development of the white apical spots is exactly similar. On the other hand, the black spots of the median and postmedian series on both surfaces are most noticeably enlarged, both in length and breadth, giving the insect at once a most distinctive appearance. This enlargement more particularly affects the postmedian spots, and it is accompanied on both surfaces by a noticeable darkening of the red-brown ground colour.

Taxila haquinus pagiensis subsp. n.

N. Pagi Is., 17.x.24. 1 ♂ (Holotype), 1 ♀ (Allotype); 18.x.24. 1 ♂ (Paratype) (*H.H.K.*).
Siberut Is., Sept. 1924. 4 ♂ (*C.B.K.* and *N.S.*).

A very well-defined race, differing from typical *haquinus* of the Malay Peninsula in many features.

♂. *Upperside.* The orange-red apical patch is much better defined, less diffuse, narrower, more crescentic in shape, brighter in colour, and well separated from both apex and termen. On the *underside*, on the other hand, it is much more extensive than in any other race, and forms a wide (5 mm.) diffuse light orange patch extending from the costa to vein 4, and from the upper median spots almost to the termen to which it runs almost parallel, resembling in this respect subsp. *zemara* Butler. The ground colour is smoky red-brown, but little of it is visible owing to the extreme expansion of the black spots, particularly those of the postmedian series on the hind-wing, which exceed those of subsp. *zemara*. The interrupted submarginal pale line, and the associated pale crescents, are smoky grey. The pair of blue-edged black triangular spots just beyond the discocellulars on both wings are practically fused together, and the associated black spots within and below the cell are also much expanded and thereby brought closer together.

♀. *Upperside.* The diagonal apical band is pale ochreous, about 5 mm. wide, and extends from the costa to within 2 mm. of the termen; it is not constricted in the middle, and is thus very much larger than in any other subspecies. The pale submarginal interrupted line is about 1 mm. wide, white, and very conspicuous. The black spotting heavy and prominent, as on the underside. *Underside.* The subapical pale ochreous area is subquadrate (except for the dusky shading of the apex itself), reaches vein 4 squarely and extends narrowly to vein 3, and fully occupies the positions of the upper median spots, which have completely disappeared (in areas 4, 5 and 6). The interrupted submarginal line is pure white, wider than on the upperside; and the area between it and the associated pale grey lunules is black, not, as is usual in the species, coloured like the ground. The usual black spots are expanded proportionately to those in the male (they are never so large as in the ♂), being much as in the female of subsp. *zemara* Butler.

The condition of the subapical band, and the strongly melanistic underside—a parallel to that of *T. thuisto melanotica*—should render this subspecies quite unmistakable.

Lycaenidae.

Cyaniriodes libna klossi subsp. n.

Siberut Is., Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂ (Holotype).

♂. Differs from typical Bornean *libna* Hew. on the upperside in having much wider black borders, to both wings, and the black discoidal spot of the fore-wing larger and square. On the underside the black basal and discal spots, and the inner zigzag submarginal line are all much more strongly developed.

This extremely pretty little emerald-green species appears to be very rare in spite of its wide range. The ♀ type of *libna* Hew. from Borneo, the ♂ type of *dorothiana* Pryer & Cator captured in Borneo by D. Cator, 2 ♂, 1 ♀ taken at Renong, Siam, by Doherty, Moore's ♀ (subsp. *andersonii*) from Mergui, 2 ♂ and a ♀ from Malaya, and the ♂ now recorded are all that are known to me.

Poritia philota Hewitson.

Siberut Is., Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The solitary male of this species obtained is in such poor condition that the identification is made with some hesitancy. The underside is darker than typical *philota* and appears to have an unusually large orange anal lunule; the upperside is almost devoid of scales; all four wings are very badly torn. It is darker on both surfaces than is subsp. *taïmana* Fruhst. from Nias.

Simiskina pharyge deolina Fruhstorfer.

Sipora, October 1924, 1 ♂, 1 ♀ (*C.B.K.* and *N.S.*); 9.x.24, 1 ♂ (*H.H.K.*).

Although in both the males obtained the blue spots forming a marginal row on the upperside of the fore-wing are relatively much larger than in the nominotypical form from Borneo, their development is not equal in both. The female is quite normal. The material available from other localities for comparison is too small to admit of satisfactory conclusions as to racial characteristics, and the specimens may be provisionally referred to the Sumatran subspecies *deolina* Fruhst.

Miletus biggsii nymphis Fruhstorfer.

Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 2 ♂, 3 ♀.

Miletus symethus batuensis Fruhstorfer.

Pulau Tello, Batu Is., Nov. 1924 (*C.B.K.* and *N.S.*). 2 ♂.
Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

The males are from the type locality of *batuensis* Fruhst., and agree precisely with the type specimen in the British Museum. Only one subspecies has been recognised in Sumatra hitherto, *acampsis* Fruhst., of N.E. Sumatra. The single female listed above does not in the least agree with this form. It agrees with the Pulau Tello males and with a long series of females in the British Museum from various localities in Southern Sumatra, which therefore should perhaps be referred also to subsp. *batuensis*. It is a question, however, whether either is really distinguishable from the Malayan subsp. *diopeithes* Fruhst.

Allotinus taras mendava subsp. n. (Pl. 2, figs. 30, 31).

Sipora, October 1924 (*C.B.K.* and *N.S.*). 1 ♂ (Holotype), 1 ♀ (Allotype).

♂. *Upperside* as in *battakanus* Fruhst. *Underside* ground colour white as in *narsares* Fruhst., but the striations are slightly more dense in the outer halves of the wings, the transverse fasciae are rather more diffuse and the submarginal dots are browner and fainter.

♀. Differs from *narsares* in the much fainter reddish-brown shading on the wing termens, and in the fainter and more diffuse, although slightly larger, submarginal dots.

Length of fore-wing ♂ 16 mm., ♀ 15·5 mm.

The single pair obtained most closely resemble the form which occurs in S.E. Sumatra, and cannot be referred to subsp. *battakanus* Fruhst., the only Sumatran form at present described. The whiter underside of both examples shows an approach to the Javanese subsp. *narsares* Fruhst. This is the first record of the species from any of the chain of islands lying off the W. coast of Sumatra.

Allotinus horsfieldi siporana subsp. n. (Pl. 1, fig. 4).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀ (Holotype).

The features which distinguish this specimen are so striking and so strictly in conformity with those that distinguish nearly all the other subspecies of Lycaenidae recognised in this paper, that there appears ample justification for assuming it to typify a good local race.

The upperside presents no characters to distinguish it from other races of *A. horsfieldi* Mre. The underside is white and reminiscent of *A. macassariensis* Holl. in the develop-

ment of the markings; the small transverse striae are unusually few in number, rather small, but dark and sharply defined; the spots of the discal band on both wings are extremely large (none measures less than 1 mm. across) and stand out prominently against the white ground colour, the reduction in the transverse striation heightening the effect.

Allotinus unicolor aphocha Kheil.

Pulau Tello, November 1924, 3 ♂, 1 ♀ (*C.B.K.* and *N.S.*). 2 ♂, 1 ♀ (*H.H.K.*).

I cannot distinguish these from the subspecies which was described by Kheil from Nias. The males exhibit a certain amount of variation in size but otherwise the series is very constant.

Allotinus nivalis sibyllina subsp. n. (Pl. 2, fig. 27).

Sipora, October 1924 (*C.B.K.* and *N.S.*). 2 ♂, 4 ♀.
Siberut, September 1924 (*C.B.K.* and *N.S.*). 2 ♂.

Nearer to typical Bornean *nivalis* H. Drc. in general features than to the Sumatran (*magaris* Fruhst.) or Nias (*lenaia* Fruhst.) subspecies, and distinguished from it by the lack of the dark marginal clouding towards the apex on the fore-wing and at the tornus on the hind-wing. This character also distinguishes it from the Malayan *substrigosa* Mre. From *lenaia* and *magaris* it is distinguished by the duskier and more evenly striate underside and by the fact that the costal spot on the underside of the hind-wing is very rarely black (only in one of eight specimens) but usually grey like the other markings.

Castalius ethion mentawiensis subsp. n.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 14 ♂, 5 ♀.
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 13 ♂ (including Holotype ♂), 1 ♀ (Allotype); 10.x.24 (*H.H.K.*). 1 ♂.
N. Pagi, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

Holds a position rather intermediate between *niasanus* Swinhoe and *ethion* Hew. (= *vavasanus* Fruhst., *colmus* Fruhst.).

♂. Ground colour rather light blue and the black border much narrower than in *ethion* from the Continent and larger islands, but twice as broad as in *niasanus*; the white band variable (as always) but generally decidedly narrow and not sharply defined.

♀. *Upperside* with very narrow and irregular white band, sharply angled at centre of its outer edge on hind-wing.

♂♀. *Underside* approaching *babiensis* v. Eecke (Simalur, Pulau Babi); all spots very large. On the fore-wing the subapical black bar is united in the majority of specimens to the usually isolated black discal spot in area 3; this in turn is (though not so often) frequently united to the large black spot on the inner margin. A similar development occurs on the hind-wing; the upper and middle large black discal spots are fully united in all but four of the 36 specimens examined, but only in one specimen is there actual union between the middle and lower spot (in *babiensis* all three are united, thus forming a continuous band).

With the exception of *airavati* Doh. (from the Nicobars), this has the most strongly melanic underside of any subspecies so far recognised. Examination of some hundreds of specimens from Ceylon, S. India, Assam, Burma and Siam convinces me that the so-called subspecies erected from these areas by Fruhstorfer (*vavasanus* etc. as given above) are quite untenable. The Sumatran subsp. *ethionides* Fruhst. is recognisably distinct from *ethion* of the Continent,

but not on the characters given by Fruhstorfer. The series from Sumatra in the British Museum are distinctly *smaller* on the average than Indian specimens and the black borders are no wider; these look wider, however, because the outward projection of the white band of the fore-wing in area 3 is much shorter than in typical *ethion*, and provides the most distinctive feature of the subspecies.

The subsp. *wehensis* Toxopeus from Pulau Weh (off north-east coast of Sumatra) is not known to me.

Castalius elna caletoides subsp. n.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 9 ♂.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 14 ♂ (including Holotype); 29.x.24 (*H.H.K.*). 1 ♂.

♂. *Upperside* only distinguishable from that of Javan *elna* Hew. by the rather narrower white band, the constriction being particularly apparent in area 1b of the fore-wing. *Underside*, the black markings extremely heavy; on the fore-wing the black basal band is inwardly shaped exactly as in typical *elna*, but outwardly much enlarged and fused broadly, towards the costa, with the transverse subapical black patch; this patch, unlike that of normal *elna*, but like that of *caleta* Hew. and *roxus* Godt., extends as a tapering bar as far as vein 3, completely uniting with the black marginal spot in that area; the large black tornal spot is enlarged and extended to vein 3, but terminates basad from the end of the subapical bar and is completely but only narrowly separated from it. The hind-wing is quite typical *elna* in all respects, differing only in the relatively somewhat larger spots.

No female was obtained.

This very distinct subspecies is remarkable for the extraordinarily close resemblance of the underside of its fore-wing to that of *roxus* or *caleta*. The basal half of the fore-wing and the whole of the hind-wing are typical *elna* in facies, but the outer half of the fore-wing has precisely the pattern typical of *roxus*, or, more exactly, of *caleta*. The pattern of *elna* is on the whole extremely constant; in a very large number of specimens examined only one has been found with an extension of the subapical bar. This is a Sikkimese male in which the bar extends a little more than half-way across area 4 on the right fore-wing, the left fore-wing being normal. The special features of the pattern are exactly those which also distinguish *C. ethion mentawiensis* from the other races of that species, the two species apparently forming an association of some kind which is all the more remarkable in that in order to do so both have departed very widely from the norm of the species without the influence of any other species. *Castalius roxus*, which one would like to look upon as the ideal pattern towards which both were being drawn, was not obtained on any of the islands visited, nor is there any record of it from any of the neighbouring groups, Simalur, Nias, Batu and Engano.

Pithecops corvus corvus Fruhst.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂, 1 ♀; 29.x.24, 1 ♂, 11.x.24, 1 ♀ (*H.H.K.*).

Pulau Tello, Nov. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

The bright fulvous postdiscal and submarginal lines of the underside, and also the black subapical spot, are extremely well developed in these examples,

as in the single *Neopithecops zalmora batuana* obtained on Pulau Tello. Possibly they should be distinguished from typical subsp. *corvus* of Sumatra, but Fruhstorfer's description is insufficient to enable one to decide this point without the aid of Sumatran material, which is lacking in the British Museum.

Neopithecops zalmora batuana subsp. n.

Batu Is., Pulau Tello, Nov. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The single specimen upon which this name is based is nearer in general features to typical Burmese *zalmora* Btlr. than to any Malayan or Sumatran examples of subsp. *horsfieldi* Dist. that I have seen. On the *upperside* the fore-wings are rather rubbed, but it appears that there is a dusky pale area of considerable extent but much obscured by grey-scaling. On the *underside*, which provides the best characters, the postdiscal line is complete and strongly developed, fully as prominent as the submarginal markings, on both wings, and is dark grey; the black subapical spot is most unusually large and measures, at its greatest width, fully 2 mm. Only in specimens from the Andaman islands, one from Burma and one from Borneo have I seen such a development of this spot; but in all these the postdiscal line is much paler in colour and less well defined.

Everes lacturnus polysperchinus Kheil.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂, 1 ♀.

The subspecies *polysperchinus* Kheil occurs in Nias; it is known to me only from the description, which applies quite well to the pair from Siberut. This, considering the great extent to which most of the Mentawi butterflies differ from those of Nias, would be remarkable, did it rest upon the examination of long series from both places.

Megisba malaya velina Fruhst.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

Agrees with Sumatran examples in having a uniformly brown upperside. The markings of the *underside*, however, are by no means "fine", but as heavy as in any wet-season ♂ of the form *sikkima* Moore.

Celastrina puspa siporana subsp. n. (Pl. 1, fig. 5).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 5 ♂ (including Holotype ♂).
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♂.
N. Pagi, 17.x.24 (*H.H.K.*). 1 ♂.

♂. *Upperside* of approximately the same shade of blue as in subsp. *lambi* Dist. (Malay Peninsula), and with the black borders equally wide except around the apex of the hind-wing. *Underside* ground colour clear uniform greyish white without any trace of brown, as in subsp. *puspinus* Kheil, which it also resembles in all other respects on this surface, except that the markings are as a whole distinctly, though not very much, larger.

An interesting link between *lambi* of Malaya and Sumatra, and the very distinct *puspinus* from Nias. The single ♂ from N. Pagi Is. approaches the latter more closely than do the others, both in the colour of its upperside and in the markings of its underside.

I have seen no examples of subsp. *vandeldeni* Toxopeus described from Pulau Weh.

Zizeeria otis Fab. subsp.

Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

Owing to lack of material I am unable to say whether this specimen should be referred to subsp. *kuli* Toxopeus from Deli, on the coast of North-east Sumatra, or to subsp. *annetta* Toxopeus from Perapat, on the banks of Lake Toba in Sumatra.

Euchrysops pandava insularis subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 14 ♂ (including Holotype).

The specimens comprising this series are well above the average in size, are dark in colour, with relatively wide black borders, and have a dark and strongly marked underside with large and prominent red anal patch—as compared with Indian and Burmese *pandava*. They are not typical *pandava* Hsf., which has a decidedly pale underside, particularly in respect of the orange patch. In these Sipora examples the width and diffuse nature of the black border on the upperside (up to 2 mm. on hind-wing, never less than 1 mm. on fore-wing) are particularly characteristic; the orange lunule in area 2 on the underside of the hind-wing is far greater than the black ocellus it encloses, and is continued in area 3 on one side and, uninterruptedly, into area 1 on the other.

Anthene emolus goberus Fruhst.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

Not distinguishable from *emolus* of Sumatra and the Malay Peninsula.

Catochrysops strabo naerina subsp. n.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 13 ♂, 2 ♀ (including Holotype ♂, Allotype ♀).
Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

♂. *Upperside* paler than in subsp. *riama* Cbt. from the Malay Peninsula, and differs from all other described *strabo* forms in that the black subtornal spot in area 2 on the hind-wing bears a narrow orange-red lunule on its inner edge. *Underside* is rather variable but shows no constant differences from *riama*.

♀. *Upperside* darker than in Malayan or Javanese females, the blue dusting on the fore-wing being very restricted and only a few blue scales visible on the hind-wing. *Underside* differs from *riama* only in the rather larger and more reddish-orange subtornal patch on the hind-wing.

The rather worn ♀ from Padang probably represents a different subspecies.

Catochrysops panormus exiguus Dist.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♂.
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 4 ♂.

The specimens agree quite well with males of the subspecies from the Malay Peninsula.

The Siberut specimens are rather more boldly marked than those from Sipora. It is remarkable that so many authors still treat this very distinct species (of which *lithargyria* Mre. is a race) as if it were a mere variety of *C. strabo* Fab.

Lampides boeticus Linn.

Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 1 ♂, 1 ♀.

The apparent absence of this cosmopolitan species from the Mentawi Islands is more remarkable than its presence there would be.

Jamides celeno caena subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 5 ♂ (including Holotype).
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

♂. The specimens differ from males of Niasese *arama* Fruhst. in the British Museum only in the broader black border on the upperside of the fore-wing, but this difference is sufficiently striking to justify subspecific differentiation. The Siberut ♂ has the wing margins too badly torn for accurate comparison with the Sipora series.

The Pulau Weh subsp. *carolina* Toxopeus is not represented in the British Museum.

Jamides zebra megana Cbt. (Pl. 1, figs. 6, 7).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 3 ♂.
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♂, 4 ♀; ix.1924 (*H. H. Karny*), 1 ♂, 3 ♀.
Mentawi, 17.x.1924 (*H. H. Karny*). 1 ♀.

The males from Sipora and Siberut are not separable on facies.

Jamides malaccanus celinus Fruhst.

Padang, W. Sumatra, Nov. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

Both specimens are rubbed but the darker upperside with broader bordering on the fore-wing agrees better with Javanese examples than with the type of *celinus* from Sumatra: on the underside, the hind-wing orange area resembles that present in *celinus* rather than in Javanese *saturatus* Snell.

Jamides parasaturatus puti subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♂, 4 ♀.
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 7 ♂, 5 ♀ (including Holotype ♂, Allotype ♀).

♂. Differs from the Malayan and Sumatran *paramalaccanus* Rly. and Cbt. ♂ only in the whiter hind-wing on the upperside.

♀. *Upperside* ground colour paler and whiter than in subsp. *paramalaccanus* ♀. Underside as in the mainland race.

Jamides alecto mentawica Hagen.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 17 ♂, 3 ♀; 1.xi.1924 (*H. H. Karny*). 1 ♀.
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

These specimens, which are quite distinct from *thanetus* Fruhst. from Nias, are provisionally referred to subsp. *mentawica* Hagen, of which no examples are available for comparison.

Jamides cunilda Snell. subsp.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*).. .1 ♂.

The specimen is rather rubbed but its identification has been confirmed by an examination of the genitalia. The upperside is paler than in any named Malaysian race and the hind-wing submarginal bordering is arranged as in the nominotypical form from Java. On the underside, the white strigae are broader than in Sumatran examples of *nisanca* Fruhst. but resemble more the Javanese race : the hind-wing orange tornal area is more extensive than in Malayan and Sumatran specimens and is similar to that found in typical *cunilda*, while the black subtornal spot in area 2 is rather larger than in other subspecies.

The condition of the specimen is too poor to allow proper description.

Jamides cyta lamax subsp. n. (Pl. 1, fig. 8).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♀ (including Holotype ♀).

♀. *Upperside* ground colour rather paler and with a more purple hue than in *leiothrix* Fruhst. ♀, from Engano; on the *underside*, the orange tornal area on the hind-wing is much more extensive.

Only a ♂ of *courvoisieri* Fruhst., from Nias, was available for comparison, but this showed the orange tornal area on the hind-wing almost as restricted as in the Engano race.

Nacaduba pavana singapura Cbt.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 2 ♂.

The Siberut specimens agree with subsp. *singapura* Cbt. from the Malay Peninsula.

Nacaduba hermus Feld. subsp.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

Appears to be this species, in which the females are very variable, and not *sanaya* Fruhst. The upperside is whiter than usual in subsp. *lysa* Fruhst., from north-east Sumatra, and on the hind-wing beneath the orange tornal area is larger and the black spot in area 2 is larger and more elongated.

Probably represents a new subspecies but the condition of the specimen is too poor for description.

Nacaduba sanaya sanaya Fruhstorfer (Pl. 1, fig. 9).

Siberut, 8.ix.1924 (*H. H. Karny*) 1 ♂; Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♀.

The ♂ agrees with nominotypical *sanaya* from Nias, except that the fore-wing apex is more acute. Both sexes differ from the truly Malaysian races of *sanaya* and agree with the Niasese form in the more extensive orange area on the hind-wing beneath. The Mentawi specimens may be placed provisionally under typical *sanaya*.

Nacaduba kurava mentawica subsp. n. (Pl. 1, fig. 10).

Sipora, October 1924 (*C.B.K.* and *N.S.*). 1 ♂ (Holotype).

I have no hesitation in identifying this specimen as *N. kurava* Moore (cf. 1927, Toxopeus, *Treubia* **9** : 423), having examined its genitalia, but its separation from subsp. *nemana* Fruhst. (of Sumatra) and subsp. *niasica* Tox. is more difficult.

On the upperside the colour is much brighter than in the former, but not quite so bright as in the latter. The white markings of the underside are less prominent than in *niasica*, but on the other hand they have the same noticeable regularity of that subspecies as compared with subsp. *nemana*; the lines are less broken, more even and straighter. One is compelled to describe it as a new subspecies because it does not precisely agree with any of those so far described; the differences, however, are of a rather indefinable nature.

Nacaduba aluta H. Drc.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The specimen is too fragmentary to permit of a proper comparison with the subspecies *nanda* de N., which inhabits Sumatra, and *lessina* Fruhst., of Nias, but in so far as it is possible to indicate an affinity, this favours the latter rather than the former. The identification has been made by comparison of the genitalia (without dissection) with those of *N. aluta nanda* figured by Fruhstorfer on Plate IV, fig. 9, of 1916, *Zool. Medd.* 2, and by comparison with Druce's Type specimen (not dissected).

Curetis bulis gé Fruhstorfer.

Sipora Is., Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The single specimen obtained may not be subspecifically distinct from the Niasese subspecies *gé* Fruhst.

Curetis sperthis niasica Fruhstorfer.

Sipora Is., Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.
Siberut Is., Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

In both specimens the underside is darker than in the Niasese representative.

Curetis hera hera Fruhstorfer.

Sipora Is., Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

The upperside is darker than in the nominotypical form from Nias, but I hesitate to propose a new subspecific name on the basis of a single female specimen in this variable genus.

Amblypodia narada smedleyi subsp. n. (Pl. 2, fig. 37).

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂ (Holotype).

♂. *Upperside* brilliant shining sky blue, as in the female of *Amblypodia amantes* Hew. Fore-wing with the whole costal area as far as the cell black; termen broadly black, the border expanding from 3 mm. wide at tornus to 9 mm. wide where it meets the black costal border. Hind-wing with the costa also broadly black, but not quite to the cell nor to the base of area 6; termen narrowly black bordered between veins 2 and 4 and then expanding in both directions, posteriorly so as to fill the whole of the abdominal area except a narrow strip along vein 2. *Underside* very dark faintly greenish brown, mottled and marked as in *A. narada taooana* Moore.

Length of fore-wing : 24 mm.

At first sight this specimen appeared to be a female of *A. anita* Horsf. with the brilliant blue characteristic of the female form *naradoides* Mre. of that

species intensified and extended to the hind-wing as well. Examination of the abdomen revealed it to be a male. The colour of the upperside is quite unlike that of any other species or subspecies in the genus, but the ♂ genitalia are identical with the Niasese form of *A. narada*.

Arhopala aedias soter Fruhstorfer.

Siberut, 28.ix.24 (*H.H.K.*). 1 ♂.

As Fruhstorfer points out, *soter* differs from Malaccan *agnis* C. & R. Feld. in its lighter blue upperside, and darker brown underside. This appears to be another instance of the Mentawi race following that of N.E. Sumatra, for in S.E. Sumatra the species has a very different aspect. The underside is darker and the markings are more obscure than in subsp. *sphetys* Fruhst. from Nias.

Arhopala atosia lurida Cbt. (Pl. 2, figs. 22, 23).

Siberut, September 1924 (*C.B.K.* and *N.S.*). 2 ♂, 3 ♀; 28.ix.30, 1 ♂; 26.ix.24, 1 ♀ (*H.H.K.*).
N. Pagi, 17.x.24, 1 ♂, 1 ♀ (*H.H.K.*).

In the light tone of the blue upperside these specimens approach the Tenasserim form generally, but incorrectly, known as *aricia* Stgr. rather than typical Sumatran *atosia*. The ground colour of the underside is quite rich brown, not grey-brown, and the dark spots are very clearly and sharply outlined.

Arhopala moolaiana klossi Cbt. (Pl. 2, figs. 24, 25).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.
N. Pagi Is., 17.x.24 (*H.H.K.*). 1 ♀.

This species occurs from S. Burma to Malaya, Sumatra and Borneo, but it has not been recorded previously from the chain of islands off the W. coast of Sumatra. The form from the Mentawi islands is remarkable in that both sexes exhibit the lustrous blue upperside found in the typical form from Burma ; in Neomalaya the upper surface is a much duller purple-blue colour.

Arhopala alitaeus psama Cbt. (Pl. 2, fig. 26).

Mentawi, 6.x.24 (*H.H.K.*). 1 ♂.
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

A. alitaeus appears to be not uncommon in S. Burma and the Celebes, but it is a very rare insect in Neomalaya and has not been recorded previously from the Paramalayan islands.

Arhopala kounga karnyi Cbt. (Pl. 2, figs. 33, 35).

Mentawi, 6.x.24 (*H.H.K.*). 2 ♂.
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀.
N. Pagi Is., Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

This species closely resembles *A. aroa* Hew. but differs not only in the more shining and bluer upperside in the male but in that the post-discal spot in 3 on the fore-wing beneath is moved out of line with the adjacent spots : in *A. aroa* the post-discal spots in areas 2, 3 and 4 are more or less in line. Both species appear to be widely distributed from South Burma to Malaysia.

Arhopala centaurus centenitus Fruhst.

N. Pagi Is., October 1924 (*C.B.K.* and *N.S.*). 1 ♂.

A very handsome race, with much darker and wider underside markings than in Sumatran *nakula* C. & R. Feld., and with the silvery-green area on the hind-wing reaching beyond vein 3 and very wide.

Arhopala cooperi siberuta Cbt. (Pl. 2, fig. 36).

Siberut, 10.ix.1924 (*H.H.K.*). 1 ♂.

The Siberut male differs from the Mergui Type ♂ only in having a slightly purplish underside ground colour, and rather more anal green.

The species is known otherwise only from Mergui, Malaya and the mainland of Sumatra.

Arhopala eumolphus Cram. subsp. (Pl. 2, fig. 34).

N. Pagi Is., Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The single specimen obtained is a good deal smaller, and rather darker on the underside, than is usual in males from the Malay Peninsula. It is probably the form which Fruhstorfer has described as *A. eumolphus caesarion*, from N.E. Sumatra.

Arhopala labuana etuna Cbt. (Pl. 2, fig. 21).

N. Pagi Is., Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

Apart from the present record, this rare species is represented in the British Museum only from the Malay Peninsula, Sumatra and Borneo.

Arhopala vihara pagia Cbt. (Pl. 2, fig. 32).

N. Pagi Is., 17.x.24 (*H.H.K.*). 1 ♂.

The black borders to the wings on the upperside are a little wider than is usual in Malayan examples.

Loxura cassiopeia ptesia subsp. n.

Sipora Is., Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♂, 1 ♀.
Siberut Is., 30.ix.1924 (*H.H.K.*). 1 ♂ (Holotype); Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♀ (including Allotype).

♂. *Upperside.* Ground colour more yellow, fore-wing black border rather narrower in the subapical area and altogether more dingy in appearance than *cassiopeia* Dist. ♂, from Malaya, or the similar *numara* Fruhst., from Sumatra. *Underside* as in the nominotypical form.

♀. *Upperside* differs from *cassiopeia* ♀ in the yellower colour and in the prominent orange streaks on the dark ground in the distal half of the hind-wing. *Underside* as in the male.

In the Sipora males the distal half of the hind-wing is darkened between the orange veins; these may represent a further race, but I hardly think further separation is justified on such scanty material.

Pratapa vidura sinhara Fruhstorfer.

Padang, W. Sumatra, November 1924 (*C.B.K.* and *N.S.*). 2 ♂.

Both specimens are in rather poor condition, but apparently are quite typical of *sinhara* Fruhst., which occurs throughout Sumatra and northward through the Malay Peninsula as far as Renong in Siam.

Cheritra freja frigga Fruhstorfer.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

Does not differ at all from Malayan and Sumatran *frigga*, but I have seen no examples of the subsp. *sabanga* Toxopeus, recently described from Pulau Weh, off the north-west coast of Sumatra.

Marmessus thesmia batunensis Fruhstorfer.

Pulau Tello, Nov. 1924 (*C.B.K.* and *N.S.*). 2 ♀.

One of the females from Pulau Tello, Batu Islands, has a large orange patch on the upper surface of the fore-wing and is clearly referable to subsp. *batunensis* Fruhst.; in the other, this patch is smaller, but not so small as in Mentawi specimens.

Marmessus thesmia pagiensis subsp. n. (Pl. 1, fig. 11).

N. Pagi Is., Oct. 1924 (*C.B.K.* and *N.S.*). 7 ♀ (including Holotype).

Four of the seven females from North Pagi are characterised by a small but proximally sharply defined orange patch, about 4 mm. long, and by grey-blue submarginal scaling on the hind-wing, which, although not wide, yet extends as far as vein 5, and almost to vein 6, in the form of a narrow tapering projection. On the underside, the maculation is heavy, but the most conspicuous feature is the extremely pale ochreous colour of the basal inner marginal areas of the fore-wing, against which the transverse bands stand out very prominently. The other 3 females are so badly damaged that their features are not recognisable. The characters are of such an order that the existence of a distinct subspecies in N. Pagi may be inferred, transitional to that occupying Sipora and Siberut.

Marmessus thesmia albicans subsp. n. (Pl. 1, figs. 12, 13).

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 11 ♂, 10 ♀ (including Holotype ♂, Allotype ♀); 22.x.24 (*H. H. Karny*) 1 ♀.
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 3 ♂, 6 ♀; 10.ix.24, 1 ♂, 22.ix.1924, 1 ♀ (*H. H. Karny*).

These 15 males and 17 females clearly represent a further island race of *Marmessus thesmia*.

♂. *Upperside* not distinguishable from *batunensis* or *thesmia* Hew. (= *minara* Fruhst.[2]). *Underside* exactly like subsp. *batunensis*, except that the ground colour of the fore-wing, instead of being smoky grey, is light grey, almost white, at least in the central area.

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[2] This name is wrongly attributed by Seitz (*Macrolep.* **9** : 987) to Hewitson. It was introduced by Fruhstorfer (1912, *Berlin. ent. Z.* **56** : 251), for "♂ and ♀ of *B. thesmia thesmia* from the Malay Peninsula and Sumatra having a red patch. This is indeed the commonest form in this region." The type specimen of *minara* in the Fruhstorfer collection is a male from north-east Sumatra, so that the name falls as a synonym of *thesmia* Hew.

♀. *Upperside,* only a very small diffuse dusky orange fore-wing patch, and with the grey-blue marginal area of the hind-wing also dusky and diffuse, not reaching as far as vein 4. *Underside,* the ground colour of the fore-wing is quite white (3 examples out of 7, including the allotype) or at most very pale ochreous indeed; the margin remains ochreous, and also the transverse discal band.

Males from Siberut are, on the average, rather less broadly marked with orange on the upperside of the fore-wing.

Examination of the male genitalia has shown that the following six species of *Marmessus* occur in the western part of the Indo-Malayan region :—*estella* Hew., *scaeva* Hew., *thesmia* Hew., *scudderii* Doh., *lisias* F. and *archbaldi* Evans : vein 9 on the fore-wing is present in all but the last two species.

Marmessus scudderii karnyi subsp. n. (Pl. 1, figs. 1, 20).

Siberut, 30.ix.24, 1 ♂ (Holotype), 22.ix.24, 4 ♀ (including Allotype) (*H. H. Karny*).

Sipora, October 1924, 1 ♂, 2 ♀ (*C.B.K.* and *N.S.*); 11.x.24, 1 ♀, 1.xi.24, 1 ♀ (*H.H.K.*).

N. Pagi, October 1924, 1 ♂ (*C.B.K.* and *N.S.*).

Pulau Tello, November 1924, 1 ♀ (*C.B.K.*).

In this distinct subspecies, both sexes have the orange discal patch on the fore-wing reduced almost to obsolescence.

♂. *Upperside.* Dark brown. Fore-wing with a very faint, obscure red-brown patch at the end of the cell, and a rather large apical patch of violet-grey scaling extending as far down as vein 2; cilia black. Hind-wing with a grey-blue area, wider than in *scudderii* from Mergui, extending from vein 6, where it is widest, to the anal angle, but nowhere fully reaching the margin; a white marginal line followed by a black anteciliar line from the anal angle to vein 3; tails black, edged and tipped with white; cilia white to vein 4, black to apex; costal area black.

Underside. Ground colour of both wings white, with the orange and brown colour of *scudderii* in the apical third and costal area of the fore-wing and apex of the hind-wing replaced by smoky brown. Markings of both wings arranged as in *scudderii*, but all spots solid black, except the discal spots of the hind-wing below vein 6, which are composed of pairs of parallel thick black lines.

♀. *Upperside* exactly like that of the male, except for the absence of the violet-grey scaling at the apex of the fore-wing and the restriction of the grey-blue area on the hind-wing to the area between the anal angle and vein 4.

Underside. On the fore-wing the white ground colour extends almost to the margin; the termen of the fore-wing (broadly) and the apex of the hind-wing (narrowly) orange-brown, and the fore-wing transverse bands also are much more orange than in the male.

Length of fore-wing ♂ and ♀ 13 mm. (in *M. thesmia* 17–18 mm.).

Two of the three males obtained are in poor condition, and have lost most of the violet-grey apical scaling on the fore-wing.

Although there is no difficulty in recognising the males, this is not the case with the other sex, and it is possible that some of the females recorded above as *karnyi* are, in fact, small females of *M. thesmia.* I have discovered no certain means of distinguishing the females of these two species.

Marmessus scudderii dohertyi subsp. n. (Pl. 1, figs. 18, 19).

♂. *Upperside.* Differs from *perlisa* in that the blue-grey scaling on the hind-wing is confined to a small patch at the cell-end, while the black submarginal spots in areas 2

and 1c are inwardly bordered by diffuse and irregular blue-grey scaling. *Underside* as in *perlisa*, except that the brownish-orange colour on the fore-wing and apical area of the hind-wing is replaced by a more smoky brown.

♀. *Upperside* as in the male, except that the fore-wing lacks the purple scaling and there is a small obscure orange-red discal patch. On the hind-wing the blue-grey area is broader and confined to the subtornal area. *Underside* as in the male.

Length of fore-wing 14 mm.

♂ Holotype and ♀ Allotype from South-east Sumatra, Marang, 1890 (*W. Doherty*). In British Museum, ex Coll. Oberthür. Also in British Museum 2 ♂, 1 ♀ same data; 1 ♂ Sumatra, ex Coll. Hewitson; 1 ♂ Borneo, ex Coll. Godman and Salvin and 1 ♂ Pulau Laut, vi.1891 (*W. Doherty*), ex Coll. Elwes.

An opportunity has been taken of figuring the types of the two recently described Malayan races of *M. scudderii* namely subsp. *biranta* Riley, from the Langkawi Is. (plate 1, fig. 16; plate 2, fig. 29), and subsp. *perlisa* Riley, from Perlis (plate 1, fig. 17; plate 2, fig. 28). There is a further subspecies of *M. scudderii* from the Sumatran mainland (1942, *Entomologist* **75** : 88).

Marmessus lisias connexa subsp. n. (Pl. 1, figs. 14, 15).

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 6 ♂, 2 ♀ (inclusive of Types).
Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♀.
N. Pagi, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

The Mentawi Islands are inhabited by a very distinct subspecies of *Marmessus lisias*.

♂. *Upperside*, fore-wing blackish-brown with an oval, sometimes proximally rather angular, transverse bright orange patch, occupying the distal third of cell, and extending into area 1b to about 2 mm. from margin. Hind-wing light silvery blue, the costal area beyond the black sex-patch broadly white to greyish, the margin with narrow black patches in areas 1c, 2 and towards the apex, a white marginal and a fine black anteciliar line. Underside as in typical *lisias* except that the ground colour of the fore-wing is very dark ochreous brown suffused to a variable amount and intensity with grey; the inner margin broadly white: on the hind-wing, the ground colour is white, including the costal area; the black spotting of both wings is very heavy.

♀. *Upperside* very dark brown. The orange patch of the fore-wing ill defined, long but narrow (about 2 × 6 mm. in ♀ allotype); the hind-wing with only very faint traces of the submarginal grey-blue suffusion common to most races of *lisias*. The *underside* resembles that of the male entirely with the important difference that the ground colour of the fore-wing is bright orange.

This new race of *lisias* from Mentawi is interesting from several points of view. It is intermediate in the ♂ between *caesarea* Weym. (= *niasica* Stgr. = *corula* Swinhoe [wrongly described as Sumatran]) and *serunica* v. Eecke from Simalur, in that the fore-wing is without the basal blue patch of the former, whilst the hind-wing has suffered none of the restriction of blue characteristic of the latter. The female has lost the wide grey-blue suffusion of the upperside of the hind-wing, so characteristic of *caesarea* ♀, but, on the other hand, the underside of its fore-wing is not like that of the male, *i.e.* blackish brown as is stated to be the case in *serunica* ♀.

These three island races can most readily be linked to those of Sumatra through a remarkable subspecies which inhabits the west coast of Sumatra

at moderate altitudes in the district of Marang, Liwa and Kroë (Res. Benkoelan), of which a long series was obtained by Doherty, and is described below :—

Marmessus lisias janus subsp. n.

♂. *Upperside*; fore-wing black, with a very small and very dark and dusky rusty red-brown patch lying mainly towards the base of area 2, but extending narrowly towards the cell end; between this patch and the wing base a roughly circular patch of variable size of silvery blue. Hind-wing silvery blue, area 8 white beyond the sex-patch; a fine black anteciliar line. *Underside*, black spots very solid and large, the ground colour pure white except for the distal half of fore-wing, which is dark grey, without any trace of ochreous. ♀. *Upperside* like that of subsp. *moorei*, except that there is always at least a very small orange discal patch. *Underside*, also like that of ♀ *moorei*, i.e. the ground colour of fore-wing and costa of hind-wing is rich ochreous (somewhat darkened distally, however).

Holotype ♂ and Allotype ♀, Marang (W. Sumatra).

The peculiarly interesting feature about this subspecies is that it has completed the sexual colour differentiation of the underside of the fore-wing begun in the island races *caesarea*, *connexa* and *serunica*, with the result that the male has become, in respect of its underside, the Javan subsp. *ravindra*, whereas the female remains of the *moorei* type. Further evidence of the close affinity of *ravindra* and *janus* is supplied by specimens of the latter obtained at the same time and place as the types, in which the orange fore-wing patch has disappeared; one insect thereby differs in no way superficially from a typical male of *ravindra*.

In view of these facts it seems no longer justifiable to regard *lisias*, *moorei* and *ravindra* as distinct species, but rather as geographical races of a single species, a view which was put forward tentatively by van Eecke as a result of an examination of the genitalia in both sexes. The apparent confusion of races in Sumatra and Borneo is readily reduced to order when more exact information as to distribution is available.

Whilst dealing with this species it may be convenient to describe two further closely related island races.

Marmessus lisias batuna subsp. n.

♂. *Upperside* like subsp. *connexa*, but the discal orange patch on the fore-wing rather smaller, regularly oval, and duskier, the veins that cross the upper part of the patch conspicuously black. Hind-wing of the same shade of blue, but the white costal area strictly confined to area 8, and separated from the blue area by a wide black space which fills the whole of area 7. *Underside* as in the Sumatran *cala* Swinhoe (= *iskander* Fruhst.) *i.e.* fore-wing underside dark brown and much clouded with dark grey; spotting of hind-wing as in *esla*, not nearly so heavy as in *connexa*; costa grey.

♀. *Upperside*. The orange discal patch on the fore-wing variable. In the type specimen it is smaller even, and more suffused than in *connexa* ♀, the only clear portion being a small triangular patch immediately contiguous to the end of the cell. On the hind-wing there is rather more grey-blue marginally than in *connexa*, and it forms a more definite band. The *underside* is like that of the male except that the ground colour of the fore-wing is whitish in the basal third, centrally rather rich ochreous, and in the outer third fuscous ochreous.

Holotype ♂, Allotype ♀, also one other male and one female from Pulau Tello, Batu Is., vii.1896, 3 ♂ Tanah Massa, Batu Is., ix.1896 (*Kannegieter*), in British Museum.

Marmessus lisias banka subsp. n.

♂. *Upperside* resembles that of subsp. *esla* Swinhoe, but the orange patch on the fore-wing is decidedly larger, occupying at least half of area 3. On the hind-wing, the costa is entirely black, and the blue area, which in tone is deeper than in *esla*, is not at all sharply defined anteriorly, but, from about vein 5, gradually merges into the black costal area. On the *underside* the spotting is moderately heavy, the spots solid black, but the ground colour of the fore-wing and of the costal area of the hind-wing is light ochreous as in subsp. *boisduvalii*.

♀. *Upperside* with a narrow, irregular transverse orange patch on the fore-wing, and no blue-grey on the hind-wing except three curved lines surmounting the barely discernible marginal black spots. *Underside* as in the ♂.

Holotype ♂, and Allotype ♀, also 2 ♂, 1 ♀ from Sungei Liat, Banka Is., in British Museum.

Marmessus archbaldi alcyma subsp. n. (Pl. 1, fig. 3).

A very distinct race of *M. archbaldi* occurs in Malaysia.

♂. *Upperside* dark brown, with the tornal third of the hind-wing dusted with blue-grey, this dusting increasing in intensity towards the margin: a rather large, elongated black submarginal spot in each of areas 2, 1c and 1b, and a very narrow white submarginal line extends from the hind-wing apex to tornus, and is outwardly bordered by a very narrow black line.

Underside markings arranged as in nominotypical *archbaldi* Evans from Mergui (Plate 1, fig. 2 ♂), but broader and blacker, and the orange colour on the fore-wing and apical area of the hind-wing in *archbaldi* is replaced by chocolate brown and confined to the apical half of the fore-wing.

Length of fore-wing 12·5 mm.

Holotype, South-east Sumatra, Marang, 1890 (*W. Doherty*). In British Museum ex Coll. Oberthür. In a second male from the same locality, the blue-grey dusting on the hind-wing is more restricted. In a male from Java (Prov. Pasuruan, Kalipari, 300–500 m., 1891 (*W. Doherty*), ex Coll. Oberthür, the chocolate-brown colour on the fore-wing beneath is not as dark.

Eooxylides tharis siberutica subsp. n.

Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 10 ♂, 10 ♀ (including Holotype ♂, Allotype ♀); 9.ix.24, 1 ♂; 11.ix.24, 1 ♂; 12.ix.24, 1 ♂; 30.ix.24, 4 ♂ (*H.H.K.*).

♂. *Upperside* differs from all other subspecies in having the basal two-thirds of areas 1a and 1b (centrally) of the fore-wing powdered with blue, but the cell is free of blue. On the hind-wing the white spots are either square or broader than long (*i.e.* much shorter than in any race except *ritsemae*[3] v. Eecke from Billiton), and heavily obscured with grey-blue scaling; and there is no spot in area 5. On the underside the marginal black markings of the hind-wing are exceptionally large, their greatest width being almost double that of the narrow white band which surmounts them; the conical spot in area 2 in particular is greatly enlarged, those in 4 and 5 also well developed—features which to a varying extent are characteristic of all the races (*enganicus* Fruhst., and *watsoni* v. Eecke) of the islands lying west of Sumatra.

[3] Seitz (*Macrolep.* **9** : 993) has transposed the subspecific names *ritsemae* and *watsoni*. *ritsemae* applies to the Billiton race, *watsoni* to that of Simalur. Van Eecke's text is somewhat confusing.

♀. *Upperside* dark brown, the white spots of the hind-wing even smaller than in the ♂, quite separated by black along the veins. *Underside* as in the ♂.

Eooxylides tharis siporana subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*), 19 ♂ (including Holotype ♂), 14 ♀; 12.x.24, 1 ♂, 1 ♀ (Allotype ♀); 10.x.24, 1 ♀ (*H.H.K.*).
N. Pagi Is., 18.x.24 (*H.H.K.*). 1 ♀.

♂, differs constantly from *E. tharis siberutica* (in the series available) in always having a small white spot at the extremity of the band, in area 5, on the upperside of the hind-wing. In the ♀ the number of spots composing the band is the same as in *siberutica*, but they are on the average larger and better defined, especially those in areas 2 and 3.

Hypolycaena erylus teatus Fruhst.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 2 ♀.
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The specimens obtained agree with others in the British Museum from the Malay Peninsula, Sumatra, Bangka and Borneo, in having a wide rich brown border on the underside of the fore-wing in the female, and also in the slightly greenish tint of the ground colour of the underside. They are referable to subspecies *teatus* Fruhst.

Rapala dieneces paradoxa subsp. n.

Sipora, Oct. 1924 (*C.B.K.* and *N.S.*). 4 ♂, 11 ♀ (including Holotype ♂, Allotype ♀).
Siberut, Sept. 1924 (*C.B.K.* and *N.S.*). 1 ♀.
N. Pagi, Oct. 1924 (*C.B.K.* and *N.S.*). 1 ♀.

♂. *Upperside.* On the fore-wing the anterior edge of the red discal patch runs in an even curve through the centre of the cell to just below the origin of vein 5, thence through area 4 to vein 4 at 2·5 mm. from termen; the outer edge is strongly dentate, and on vein 2 is only 1 mm. from termen; on the hind-wing the red area is, on the other hand, unusually restricted, the costal black area being so extensive as to leave marginal red patches only 2 mm. long in area 6 and 3 mm. long in area 5. On the *underside* the ground colour is quite typical, the black spot against the margin in area 2, however, instead of being perfectly round, is very definitely elongate, being about 1½ times as long as broad.

♀. *Upperside* presents no especial features. The *underside* has, however, the same rather dark ground colour as the male.

Certain Burmese specimens from Tounghoo, Tenasserim, have the fore-wings with a red patch almost as extensive as in *paradoxa*, but in these the hind-wings differ. The wide costal black patch of *paradoxa* occurs in individuals of other races, but is always there accompanied by a marked decrease in the extent of the red area of the fore-wing. In no other race yet known is the black marginal spot in area 2 on the hind-wing underside elongate as in *paradoxa*.

In Seitz, *Macrolep.* **9**: 1002, *R. dieneces* is united with *R. suffusa* Moore under the name of *R. xenophon* Fab. Whatever may be the correct application of the Fabrician name,[4] a glance at the original description would show

[4] Butler, 1870, *Cat. Fab. Lep.*: 189, who had access to the typical figure in Jones's unpublished *Icones*, identified it as a S. American species.

that it could not apply to either of these species, which moreover are abundantly distinct. Part of the confusion is no doubt due to the failure of authors to connect the *R. suffusa* of Moore with Distant's *barthema*, both of which are subspecies of *R. dioetas* Hew. The Malaysian races of these two species have been listed by Corbet (1939, *Proc. R. ent. Soc. Lond.* (B) **8** : 109).

Rapala manea Hew. subsp.

Sipora, October 1924 (*C.B.K.* and *N.S.*). 1 ♂.

The specimen from Sipora has a very clear grey underside with prominent bands and strongly developed silver markings towards the anal angle of the hind-wings, all of which are features found equally well developed in *manea* from other small island groups such as the Andamans and Nias. Probably this type of underside is characteristic of the *manea* of such areas—approaching much more closely to typical *manea* than to its continental subspecies *schistacea* Moore.

Rapala manea chozeba Hew.

Padang, W. Sumatra, November 1924 (*C.B.K.* and *N.S.*). 1 ♂.

Approaches the Sipora form to some extent, but has the purplish-brown underside and less developed silver colour of typical *chozeba*.

Sinthusa nasaka fulva subsp. n.

N. Pagi Islands, 17.x.24 (*H.H.K.*). 1 ♂ (Holotype).

♂. *Upperside.* Compared with Horsfield's type specimen of *nasaka* the upperside presents no distinguishing feature. The ground colour of the *underside* is slightly darker, and certainly greyer, and the silvery scaling towards the anal angle is more extensive and prominent. The chief difference, however, lies in the marginal markings of the hind-wing: between vein 4 and the apex these are relatively quite well defined; below vein 4 (in area 3) there is an intensely black spot, very nearly as large as that in area 2 (the normal unpupilled eyespot) and pupilled with silver; both these spots, and the silver-covered spot in 1c, are completely and widely surrounded by a very conspicuous bright orange patch which, starting as a line at the extremity of vein 1a, commences to expand just before vein 1b, and ends squarely on vein 4, and is, throughout most of its length, very nearly as broad as the black spots which it encloses.

S. nasaka fulva is most like the Malayan *S. nasaka amba* Dist., but in the width and brilliance of the orange anal patch on the underside of the hind-wing, as well as in the development of the second marginal ocellus in the same region, is only very distantly approached by a few examples of that subspecies.

Sithon nedymond klossi subsp. n.

Siberut, September 1924 (*C.B.K.* and *N.S.*). 1 ♂ (Allotype).
Sipora, October 1924 (*C.B.K.* and *N.S.*). 1 ♀ (Holotype).

Seitz (Seitz, *Macrolep.* **9** : 978) has asserted that typical *nedymond* of Cramer comes from W. Java. A most casual examination of Cramer's published figure should have prevented his making such a claim. Cramer's original drawing is in the British Museum and shows a male with rather restricted blue areas on the upperside, and, on the underside, a prominent white line dividing the outer dark area of the fore-wing into a distal light brownish-grey half and an inner intensely dark chocolate-coloured band. The

most striking feature of Javanese specimens is the complete absence of this white line and the very slight difference in tone of the two areas it would normally separate. Typical *nedymond*, it may safely be asserted, never came from Java, but almost certainly originated in Sumatra, for, in a series of over 100 specimens now in the British Museum, those from Sumatra and Malaya agree best with Cramer's figure. Fruhstorfer's *megabates* from North-east Sumatra therefore becomes a synonym of true *nedymond*, the female of which is blackish on the upperside with rather well-developed spots in the white anal area, and, on the underside of the fore-wing, has the basal area distinctly more yellowish, less ochreous than the distal area, but without the sharp separation of these two colours which distinguishes the females of *ismarus* Fruhst. from Burma.

The single pair obtained present such a curious combination of characters that it is impossible to assign them to any known subspecies. They may be described as follows:—

♂. *Upperside* presents no particular features unless it be a somewhat unusually narrow blue border to the hind-wing. On the *underside* the brown outer areas of both wings are very dark, the contrast between their two halves not very great, and the white dividing line (of fore-wing) absent; on the hind-wing this dark area is broad, almost parallel to the outer margin, and largely replaced in its posterior third by bright ochreous; the black transverse line which runs from the inner margin across the white portion of the hind-wing in areas 1b and 1c is exceedingly narrow, partly absent.

♀. *Upperside* black, the white anal area of hind-wing enclosing two large, equal but rather diffuse black spots. *Underside.* The basal area of the fore-wing light yellow, sharply divided from and contrasted with the remaining ochreous outer area; costa of hind-wing also yellowish. The silvery markings very heavily and broadly bordered with black distally, and succeeded by an irregular black band of considerable width in area 4, which is, however, much narrower in area 5; a similar black patch quite close to the tornus of fore-wing.

The upperside is that of a typical *nedymond*, the underside that of *ismarus* except for the strong melanic tendency.

Explanation of Plate 1.

Fig. 1. *Marmessus scudderii karnyi* subsp. n. ♀ Allotype. Siberut.
2. *Marmessus archbaldi archbaldi* Evans. ♂. Lower Burma, Tavoy.
3. *Marmessus archbaldi alcyma* subsp. n. ♂ Holotype. S.E. Sumatra.
4. *Allotinus horsfieldi siporana* subsp. n. ♀ Holotype. Sipora.
5. *Celastrina puspa siporana* subsp. n. ♂ Holotype. Sipora.
6. *Jamides zebra megana* Cbt. ♂ Holotype. Siberut.
7. *Jamides zebra megana* Cbt. ♀ Allotype. Siberut.
8. *Jamides cyta lamax* subsp. n. ♀ Holotype. Sipora.
9. *Nacaduba sanaya sanaya* Fruhst. ♂. Siberut.
10. *Nacaduba kurava mentawica* subsp. n. ♂ Holotype. Sipora.
11. *Marmessus thesmia pagiensis* subsp. n. ♀ Holotype. North Pagi.
12. *Marmessus thesmia albicans* subsp. n. ♂ Holotype. Sipora.
13. *Marmessus thesmia albicans* subsp. n. ♀ Allotype. Sipora.
14. *Marmessus lisias connexa* subsp. n. ♂ Holotype. Siberut.
15. *Marmessus lisias connexa* subsp. n. ♀ Allotype. Siberut.
16. *Marmessus scudderii biranta* Riley. ♂ Holotype. Langkawi Is.
17. *Marmessus scudderii perlisa* Riley. ♂ Holotype. Perlis.
18. *Marmessus scudderii dohertyi* subsp. n. ♂ Holotype. S.E. Sumatra.
19. *Marmessus scudderii dohertyi* subsp. n. ♀ Allotype. S.E. Sumatra.
20. *Marmessus scudderii karnyi* subsp. n. ♂ Holotype. Siberut.

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New Lycaenidae from the Mentawi Islands

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Explanation of Plate 2.

Fig. 21. *Arhopala labuana etuna* Cbt. ♀ Holotype. North Pagi.
22. *Arhopala atosia lurida* Cbt. ♂ Holotype. Siberut.
23. *Arhopala atosia lurida* Cbt. ♀ Allotype. North Pagi.
24. *Arhopala moolaiana klossi* Cbt. ♂ Holotype. Sipora.
25. *Arhopala moolaiana klossi* Cbt. ♀ Holotype. North Pagi.
26. *Arhopala alitaeus psama* Cbt. ♂ Holotype. Mentawi Is.
27. *Allotinus nivalis sibyllina* subsp. n. ♂ Holotype. Sipora.
28. *Marmessus scudderii perlisa* Riley. ♂ Holotype. Perlis.
29. *Marmessus scudderii biranta* Riley. ♂ Holotype. Langkawi Is.
30. *Allotinus taras mendava* subsp. n. ♂ Holotype. Sipora.
31. *Allotinus taras mendava* subsp. n. ♀ Allotype. Sipora.
32. *Arhopala vihara pagia* Cbt. ♂ Holotype. North Pagi.
33. *Arhopala kounga karnyi* Cbt. ♂ Holotype. Mentawi Is.
34. *Arhopala eumolphus* Cram. subsp. ♂. North Pagi.
35. *Arhopala kounga karnyi* Cbt. ♀. Sipora.
36. *Arhopala cooperi* Evans *siberuta* Cbt. ♂ Holotype. Siberut.
37. *Amblypodia narada smedleyi* subsp. n. ♂ Holotype. Siberut.

(Undersides of all specimens shown, except in figs. 28, 29 and 37.)

FURTHER STUDIES ON THE METENDOSTERNITE IN COLEOPTERA

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With Plates 1–10 and Four Figures in the Text.

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I. Introduction and Acknowledgments.

This paper is intended to be studied in conjunction with Snodgrass's monograph on the Insect Thorax (47), and a previous paper by myself on the Metendosternite in Coleoptera. I accept Snodgrass's conclusions with one principal qualification—that a metendosternite consisting of a pair of arms (apophyses of Snodgrass), while it may be primitive in exopterygote insects, is certainly not so in beetles. This was established in my 1938 paper, in which it was also shown that a large section of Coleoptera–Polyphaga had a furca derivable from a type resembling that of the family Lymexylonidae (7). Reasons were adduced for supposing that this "Hylecoetoid" furca is not polyphyletic in origin, and should therefore be a character of major importance in taxonomy. In the present paper the furca of some forms not studied previously is described, figured, and discussed. The species dealt with nearly all possess primitive or annectant features so that they might be expected to throw light on the relationships of other beetles. The objects of this study are twofold—to test further the theory of the origin of the Hylecoetoid furca, and to assist in settling the taxonomic position of the forms studied.

The techniques employed were as in my previous paper, and the drawings are strictly comparable with those of the plates of that paper although they are not lettered in the same way.

The majority of the specimens were studied in the British Museum collections, through the great kindness of Dr. K. G. Blair and Dr. H. E. Hinton, while Dr. F. van Emden supplied a number of very interesting Caraboid forms from his own collection. Many of the British species were taken from the collection of the Tunbridge Wells Museum, where, with the kind encouragement of Dr. Given, the present study was carried out. Important suggestions

were received in letters from Dr. A. G. Böving, Dr. W. T. M. Forbes, and Dr. R. d'Orchymont. The friendly advice and criticism of Dr. Hinton and Dr. van Emden during the preparation of this paper have contributed much to whatever value it may possess.

II. Basic Types of Furca.

All forms of coleopterous metendosternite appear to have been derived from a single ancestral form resembling that of the modern genus *Cupes*, which I propose to refer to as the Cupedoid furca. A special and distinctive modification of the Cupedoid furca has been shown to occur in the Lymexylonid genus *Hylecoetes*, and appears to be the ancestral form for a large section of the suborder Polyphaga. This furca will be referred to as the Hylecoetoid furca. Before going on to describe the furcae of the newly-studied forms I shall give a short account of these two important basic types.

In *Cupes* and other primitive beetles the metasternum has two well-marked sutures—a transverse one and a median longitudinal one, each represented internally by a sharp ridge (pl. 1 fig. 1). The transverse (sternal of Snodgrass) suture divides the sternum into two parts, the anterior called by Snodgrass the basisternum, and the posterior furcisternum. The latter, as its name implies, bears the furca. The furcisternum has at the middle of its posterior edge a narrow projection which separates the hind coxae and bears on either side a condyle for the sternal articulation of the hind coxa. The apex of this projection may be truncate or more or less deeply cleft (*e.g.* pl. 5 fig. 38). From this projection arises the *stalk* of the endosternite, which is more or less of the same width as the apex of the projection (pl. 1 fig. 3). The stalk has a *ventral median flange*, which is at the base continuous with the dorsal ridge of the longitudinal suture of the sternum, and only parts company with the latter where it is crossed by the ridge of the transverse sternal suture. The stalk of the furca is inclined at an angle of about 30 degrees to the plane of the sternum. Some distance from its base, the stalk broadens and reaches its greatest width above the sternal suture. At this point the furca bears a ventral transverse flange, deepest in the middle and narrowing laterally. This flange crosses the median longitudinal flange, and is continuous in the middle with the dorsal flange of the transverse sternal suture. The transverse ventral flange of the furca I have called the *ventral process*, while the widest part of the furca will be referred to as the *crux* (*i.e.* the crossing-point of the two ventral flanges). In front of the crux the furca narrows again to a more or less elongate *median projection* (pl. 1 fig. 2). The median projection may be as long as or longer than the basal part of the furca, and ends somewhere near the level of the front margin of the metasternum, giving rise to a pair of tendons which run forwards into the mesothorax. The median projection may be differentiated into the postero-central more sclerotised part (the *central sclerotisation*) and a more membranous part or *lamina*.

The Hylecoetoid furca (pl. 1 fig. 4) differs from the Cupedoid chiefly in the structure of the crux region. The sternum rarely has a distinct transverse suture, and the primitive relation between that and the ventral process is lost. The latter shows a very characteristic development of its lateral portions accompanied by a reduction of the central part. The line of junction of the ventral process with the body of the furca is bent forward at each side to meet the front edge of the crux, and the ventral process may at this point become continuous with the lamina of the front of the furca, while the central sclerotisa-

tion is drawn out into lateral arms. In the majority of furcae derived from the Hylecoetoid type the median projection is lost and the anterior tendons are separated.

III. New descriptions of species not previously examined.

1. *Micromalthus debilis* Lec. (Fam. Micromalthidae). (Pl. 1 fig. 5.)

This is a small insect, in general form rather like *Hylecoetes* but rather less elongate. The metasternum is unusually large, and nearly twice as long as it is wide. There is no transverse suture, and the longitudinal suture only extends about a quarter of the length of the sternum. The furca is very small, its total length being not much more than a fifth of that of the sternum, and the width of the furcal arms is only about a fifth of the width of the metathorax. There is a well-sclerotised stalk, inclined rather steeply to the plane of the sternum, bearing at its front end the furcal arms, which curve forward. The ventral process is apparently represented by a downward projecting flange across the front edge of the furca. From the middle of the front edge to the furca arises a narrow, thinly sclerotised median projection which soon divides to form the two anterior tendons. From the large metathorax and small degenerate furca I should deduce that the imago of *Micromalthus* flies well but makes little use of its legs.

2. *Lepicerus horni* Shp. (Fam. Lepiceridae = Cyathoceridae).

Lepicerus (= *Cyathocerus*) is a small insect similar in form to an Elmid or *Georyssus*. The metasternum is about twice as broad as it is long, with a complete longitudinal suture and a short incomplete transverse suture near the hind margin. The hind coxae are separated by about a quarter of the width of the sternum, and from the inner articulations of the coxae arise a pair of rods which project in an antero-dorso-lateral direction till their ends are almost in contact with the pleural ridges at points about one-third of the way along the latter. This is all that I can certainly distinguish of the furca in my preparation.

3. *Calosoma schayeri* Er. (Fam. Carabidae). (Pl. 1 fig. 6.)

Unlike *Carabus*, *Calosoma* is a winged insect, consequently it has a better developed metasternum, about one-sixth as long as the whole body in the middle line (in *Carabus* only one-eighth). The furca correspondingly has a longer stalk than that of *Carabus*, in this respect resembling *Cicindela*. The latero-ventral projections bearing the tendons of the furco-lateralis muscle are very strong and are clearly separated from the similar dorso-lateral projections which bear the tendons of the furco-dorsalis muscles. The median anterior rounded excavation (characteristic of Carabidae) is rather longer and narrower than in *Carabus*. The ventral process is apparently represented by a downward flange along the posterior border of the median excavation, as I think is the rule in Carabidae. As in all Carabidae that I have seen, the anterior tendons arise at the front angles of the median excavation. Perhaps the most important difference between this and the *Carabus* furca is that in the latter the line of junction of the ventro-lateral and dorso-lateral projections lies at some distance from the margin of the median excavation, while in *Calosoma* it coincides with the edge of the excavation.

4. *Ceroglossus chilensis* Kr. (Fam. Carabidae).

The species of this genus closely resemble *Carabus* in general form, as well as in the structure of the metasternum and furca. The stalk is shorter than in *Calosoma*, the median excavation is unusually small, and the dorso-lateral and latero-ventral projections are similar to those of *Carabus* but less well developed. Cf. 7,* pl. 12 fig. 1.

5. *Pseudozaena orientalis* Klug (Fam. Carabidae). (Pl. 1 fig. 8.)

The form of this insect is exceptionally elongate and almost parallel-sided; the metasternum is almost as long as it is wide. The furca is extraordinarily narrow, its greatest width (at the front end) being only about a seventh of the width of the sternum, although it is almost as long as the latter. Nearly two-thirds of its length is made up by the narrow stalk, which gives rise to two narrow and almost parallel arms—the latter somewhat broadened and thinner towards their ends. The latero-ventral projection is represented only by the narrow tendons of the furco-lateralis muscles.

6. *Tefflus hacquardi* Chd. (Fam. Carabidae). (Pl. 2 fig. 9.)

Tefflus is a very large insect of typical Carabid form; it is wingless and has the metasternum similar in form to *Carabus* and *Ceroglossus*. The furca is not unlike the Carabini type in general form, but has more drawn-out lateral arms and the ventro-lateral projections appear to be partially fused to the dorso-lateral ones.

7. *Panagaeus quadripustulatus* Stm. (Fam. Carabidae). (Pl. 2 fig. 10.)

A familiar British insect of moderate size and broad form. The furca is of a typical Harpaline type, with only small differences from such forms as *Harpalus* and *Amara*.

8. *Hexagonia pallida* Chd. (Fam. Carabidae).

A small insect of rather narrow, flattened form. The furca does not differ markedly from that of the last insect, except in the latero-ventral processes, which appear to arise from the sides of the median excavation as in *Calosoma*.

9. *Lebia chlorocephala* Hoff. (Fam. Carabidae). (Pl. 2 fig. 11.)

Lebia is similar in size and shape to *Panagaeus*; the furca is of the Harpaline type but has the latero-ventral projections unusually developed.

10. *Dromius quadrimaculatus* L. (Fam. Carabidae). (Pl. 2 fig. 12.)

Of considerably smaller and narrower form than the preceding species. The furca is of more slender form and the latero-ventral processes are not specially modified; the dorso-lateral projections, which in *Lebia*, as in *Hexagonia* and *Clivina*, are well differentiated, are here represented only by the widenings of the furcal arms at the end. The furca is not unlike those of *Bembidion* and *Asaphidion*.

11. *Brachinus crepitans* L. (Fam. Carabidae). (Pl. 2 fig. 13.)

This familiar insect resembles *Lebia* in size and shape, but the furca is strikingly different and in shape more like *Dromius*. But in the relations of the

* These numerals refer throughout to the numbered bibliography, p. 308.

dorso-lateral and latero-ventral processes (which are probably of more phylogenetic importance) it differs widely from the latter genus and is probably more primitive.

12. *Triaenogenius carinulatus* (Fam. Carabidae). (Pl. 2 fig. 14.)

In general shape this insect resembles *Brachinus* but is of more than double its dimensions. Correspondingly the furca is much stronger, both the stalk and the arms being strongly broadened. The dorso-lateral and latero-ventral projections are not clearly separated, and the ventral process is unusually sharply differentiated. This furca is evidently specialised and possibly derived from a *Brachinus*-like type.

13. *Anthia alternata* (Fam. Carabidae). (Pl. 2 fig. 15.)

In size and shape closely resembling *Tefflus*, the present insect has a very different and obviously more specialised furca. In general shape it resembles the last, but is larger and stronger, the lateral arms ending almost in contact with the pleural ridge close to the anterior end of the latter. The dorso-lateral and latero-ventral projections are not differentiated, and the median excavation is unusually small. The last character is one that might be regarded as primitive, but in *Anthia* the ventral process appears to be some distance posterior to the edge of the median excavation (a character shown to a less degree in *Triaenogenius*) which suggests that the small size of the excavation is secondary.

14. *Nebria brevicollis* F. (Fam. Carabidae). (Pl. 1 fig. 7.)

The furca of this common British insect closely resembles those of *Notiophilus*, *Leistus* and *Elaphrus* and may be taken as a type of the smaller Carabinae. In structure it is very close to *Calosoma*, but as is usual in smaller insects it is of more slender construction. This furca is also very close to that of *Hygrobia* (*Pelobius*)—cf. 7, pl. 12 fig. 3.

15. *Amphizoa insolens* Lec. (Fam. Amphizoidae).

A moderate-sized somewhat flattened ovate insect, which in the structure of the metasternum has a marked resemblance to *Hygrobia* (*Pelobius*), but has the posterior coxae less strongly developed. As in *Hygrobia* the transverse suture is short and close to the hind margin of the sternum. The furca is much like those of *Hygrobia*, *Nebria* etc., but relatively smaller.

16. *Pteroloma forsstromi* Gyll. (Fam. Silphidae). (Pl. 3 fig. 16.)

In size and general appearance this species shows a striking resemblance to a small Carabid, e.g. *Harpalus*. The metasternum is somewhat wider than long, without evident sutures. The metendosternite is large and strongly sclerotised, with a long stalk (about two-thirds as long as the sternum) and furcal arms projecting antero-dorso-laterally which are nearly as long as the stalk. The median projection is short and emarginate between the distinctly separated anterior tendons. The ventral process takes the form of a flange continuous across the middle of the furca and extending under the arms.

17. *Necrophilus hydrophiloides* Mann. (Fam. Silphidae). (Pl. 3 fig. 17.)

Rather larger and more transverse in form than the last species; the metasternum is quite twice as broad as long, and the furcal arms point dorso-laterally.

The anterior tendons are rather less separated than in *Pteroloma*. Otherwise the two furcae are very similar, and not very different from *Phosphuga*, while apparently less primitive than *Thanatophilus* or *Necrophorus*. Cf. 7, pl. 9 figs. 7–8.

18. *Metopsia clypeata* Müll. (Fam. Staphylinidae). (Pl. 3 fig. 18.)

A small insect of rather short, broad form; the metasternum is nearly twice as broad as it is long, and as in Staphylinidae and Silphidae generally it lacks sutures. The hind coxae are close together and the furca has a narrow base but broadens rather quickly towards the furcal arms, which are somewhat in front of the middle of the sternum and extend for more than half its width. In front the furca is sharply truncate with a distinct downward-projecting flange along the front margin. There is a distinct posterior sclerotisation, from which two spurs project forward for some distance and give rise to the anterior tendons, the latter being separated by more than a third of the width of the furca. The ventral process is not certainly identifiable. This furca resembles Omaliinae, e.g. *Phyllodrepa*, as well as *Megarthrus*. Cf. 7, pl. 10 figs. 5, 8.

19. *Syntomium aeneum* Müll. (Fam. Staphylinidae). (Pl. 3 fig. 21.)

Smaller than the last, and almost as broad in form, this insect has a metasternum of very similar proportions. The furca consists essentially of a strong stalk, about two-thirds as long as the sternum and steeply inclined to it, giving rise to strong lateral arms which curve somewhat forward and span more than a half the width of the metathorax. The anterior tendons are widely separated, and the ventral process apparently as in Silphidae. Cf. 7, pl. 10 fig. 9.

20. *Oxyporus rufus* F. (Fam. Staphylinidae). (Pl. 3 fig. 19.)

A familiar British species, of which I suggested in my last paper (7) that the furca would prove to be close to the primitive type of *Megalopsidia*. This prediction has been verified; the chief differences in the furcae are the longer stalk, narrower anterior projection and strong muscle-discs at the ends of the arms in *Oxyporus*. The furcal arms in *Oxyporus* are also exceptionally steeply inclined to the horizontal, so that they project more dorsally than laterally—this is undoubtedly a specialised character. Cf. 7, pl. 10 fig. 1.

21. *Osorius puncticeps* Shp. (Fam. Staphylinidae). (Pl. 3 fig. 20.)

In general shape *Osorius* is about intermediate between the last species and a *Staphylinus*; the furca is similar to those of the Staphylininae but probably more primitive in the less widely separated anterior tendons and the longer projections bearing them—in these respects *Osorius* resembles Oxytelinae.

22. *Micropeplus porcatus* F. (Fam. Staphylinidae or Micropeplidae). (Pl. 4 fig. 27.)

Micropeplus is like *Metopsia* in general form; the metasternum is not quite as transverse as in the latter and the hind coxae are widely separated. As in most beetles with the latter character, the furca consists essentially of a pair of diverging arms arising from the points of articulation of the coxae. Each arm expands at its apex into a broad flattened muscle-disc. Between the arms are a pair of projections bearing the anterior tendons, which are not as widely separated as the hind coxae.

23. *Euplectus* sp. (Fam. Pselaphidae). (Pl. 3 fig. 22.)

This genus has not the specialised aspect of many Pselaphids, but is distinctly Staphylinid-like. The furca consists of a short stalk bearing arms which curve forward and bear short lateral projections near their apices. It may be compared with the Staphylinids *Phloeocharis* and *Siagonium*. The related European genus *Faronus* will probably prove to have a still more primitive furca.

24. *Pselaphus heisei* Hbst. (Fam. Pselaphidae). (Pl. 3 fig. 24.)

This insect is of much more specialised aspect than the preceding, and the furca is correspondingly modified. The hind coxae are separated, so the base of the furca is correspondingly broad; there is no stalk but only a pair of arms of a peculiar structure bearing the anterior tendons. *Tychus niger* has almost the same furca.

25. *Bythinus curtisii* Leach (Fam. Pselaphidae). (Pl. 3 fig. 23.)

This also is a specialised Pselaphid and the furca can similarly be described as a pair of arms, but it differs considerably from the last. Cf. 7, pl. 11 fig. 2.

26. *Ochthebius impressus* Marsh. (Fam. Hydrophilidae or Limnebiidae). (Pl. 4 fig. 25.)

A small, ovate rather flattened beetle; the metasternum is more than twice as broad as long and as in *Limnebius* and *Hydraena* lacks both the transverse and the longitudinal sutures (in *Hydrochus* the longitudinal one is weakly indicated). The hind coxae are close together and the furca has a narrow base. The stalk extends for a distance equal to half the length of the sternum before giving rise to the lateral arms. There is a short truncate median projection bearing the separated anterior tendons, and the posterior sclerotisation forms a strong bar between the furcal arms as in Haplogastran furcae generally. The ventral process extends on each side under the arms, and is drawn forward ventrally in the middle. The furca of *O.* (*Henicocerus*) *exsculptus* is similar but has the lateral parts of the furca rather more strongly developed, thus approaching *Limnebius*; *Hydrochus angustatus* is intermediate between *Ochthebius* and the specialised furca of *Hydraena*. Cf. 7, pl. 11 figs. 8, 10.

27. *Spercheus emarginatus* Schal. (Fam. Hydrophilidae or Spercheidae). (Pl. 4 fig. 26.)

Spercheus is much larger than the preceding species, of broader and more convex form. The metasternum is very short, but the furca is large and strong with a stalk fully as long as the metasternum in the middle line and bearing the furcal arms, which themselves are long and diverge at an angle of about 120 degrees. In consequence of the large furca and short metathorax the anterior tendons are practically eliminated, the middle of each furcal arm being directly connected by a short muscle with the mes-endosternite. The ventral process differs from those of other Hydrophilidae in having its lateral parts drawn out in a peculiar way resembling the Hylecoetoid furca.

28. *Dascillus cervinus* L. (Fam. Dascillidae). (Pl. 4 fig. 28.)

The furca of this species was incorrectly figured (from a damaged specimen) in my last paper, so I give a new figure and description. Metasternum about three times as broad as long, with complete longitudinal and transverse

sutures, the latter close to the hind margin. Hind coxae contiguous, furca with a rather broad stalk, short incipient lateral arms, a median projection of the same breadth as the stalk but shorter than it, with an emargination between the anterior tendons in front. Posterior sclerotisation distinct, ventral process extending under the hind margins of the incipient arms on each side; in the middle drawn out postero-ventrally to connect with the flange of the sternal suture.

29. *Artematopus rotundicollis* Ch. (Fam. Dascillidae). (Pl. 4 fig. 29.)

Of shorter and broader form than *Dascillus*, the metasternum of a form similar to that genus, with the longitudinal suture only extending two-thirds of its length, and the transverse suture very close to the hind margin. Furca with a longer and narrower stalk than *Dascillus*, with the median projection broader and shorter, the posterior sclerotisation relatively smaller, and the ventral process not apparently connected with the flange of the sternal suture. This form is easily derivable from the preceding.

30. *Eulichas sikhimensis* Pic (Fam. Dascillidae ?). (Pl. 4 fig. 30.)

This rather large insect has a facies much like some Elateridae and Buprestidae. The metasternum is unusually strongly curved up at the sides; the longitudinal suture is well marked but the sternal suture, as in the last species, is very close to the hind margin. The furca is nearly as long as the sternum, with a long stalk and a median projection bearing close anterior tendons, with the crux region broadened but without distinct lateral arms. The posterior sclerotisation is well marked, while the strong ventral process is drawn far forward in the middle line, and has no evident connection with the flange of the sternal suture.

31. *Callirhipis* sp. (Fam. Rhipiceridae). (Pl. 4 fig. 31.)

Very similar to the last species in general form but smaller; the metasternum and furca are also very like *Eulichas*, the principal difference being the ventral process which in *Callirhipis* is less curved but more drawn out in a postero-lateral direction.

32. *Helodes marginata* F. (Fam. Helodidae or Dascillidae). (Pl. 4 fig. 32.)

In shape *Helodes* resembles a shortened *Dascillus*, but is about half the length of the latter. The metasternum is like that of *Artematopus* in form, with the transverse suture very close to the hind margin. The furca is rather large, with some resemblance to that of *Dascillus*; it differs in the arms, which are stronger and antero-lateral instead of lateral, in the shorter median projection, and above all in the ventral process. This last in *Helodes*, as in *Cyphon* and *Macrohelodes*, has ear-like postero-ventro-lateral processes and no evident connection with the flange of the sternal suture. The lateral margins of the ventral process project forward under the bases of the arms in a peculiar manner, a character less marked in *Cyphon* and not shown by the shortened furca of *Macrohelodes*. Cf. 7, pl. 8 fig. 2.

33. *Eucinetus infumatus* Lec. (Fam. Eucinetidae or Helodidae). (Pl. 4 fig. 33.)

This insect, which resembles a rather large and elongate *Cyphon*, has the hind coxae very strongly developed and the furca extremely large and strong,

presumably in connection with its jumping habits. In shape the furca recalls that of *Cyphon* but is as wide as the entire metathorax (in *Cyphon* only about two-thirds the width), has a deep channel down its centre, apparently lacks the posterior sclerotisation, and has not the characteristic Helodid ventral process. Indeed, I have not been able to recognise certainly any ventral process in this very specialised furca.

34. *Ptilodactyla* sp. (Fam. PTILODACTYLIDAE or DASCILLIDAE). (Pl. 5 fig. 34.)

In form resembles *Artematopus*, but smaller; metasternum about twice as broad as long, with the longitudinal suture extending half its length and a very short trace of the sternal suture near the posterior border. Furca with a long stalk and a trapezoidal-shaped "head," anterior tendons separated, ventral process under the base of the "trapezoid," drawn forward ventrally in the middle line.

35. *Psephenus usingeri* Hint. (Fam. DRYOPIDAE or PSEPHENIDAE). (Pl. 5 fig. 35.)

Of rather flattened ovate form and smaller than the last. Metasternum with complete longitudinal suture and well-marked sternal suture, the latter curving forward on each side. Furca differing from the last in the shorter stalk, the presence of a distinct posterior sclerotisation, the closer anterior tendons, and in the ventral process which as in *Dascillus* preserves its connection with the flange of the sternal suture.

36. *Pelonomus* sp. (Fam. DRYOPIDAE). (Pl. 5 fig. 36.)

Larger and more parallel-sided than the last, metasternum of similar form but sternal suture straight, complete and rather near hind margin. Furca resembling last two, stalk shorter than in *Ptilodactyla*, posterior sclerotisation present but weaker than in *Psephenus*, anterior tendons separated as in *Ptilodactyla*, ventral process drawn forward in the middle ventrally, then narrowly backward to join flange of sternal suture. Differs very little from *Heterocerus* (7); more primitive than *Dryops*.

37. *Sostea* sp. (Fam. DRYOPIDAE). (Pl. 5 fig. 43.)

Of more ovate form than *Dryops*, smaller than *Pelonomus*. Metasternum similar to the last, but longitudinal suture incomplete. Furca very narrow, weakly sclerotised; stalk long, gradually broadened to the front of the furca, anterior tendons separated, posterior sclerotisation not evident, ventral process extending to the front corners of the furca at the sides, in the middle drawn far back, crossing the middle line a little anterior to the middle of the furca, not evidently connected with the flange of the sternal suture. Compare *Cyphon*, *Lutrochus*, *Byrrhinus*.

38. *Potamodytes ochus* Hint. (Fam. DRYOPIDAE or ELMIDAE). (Pl. 5 fig. 37.)

Larger and more elongate than *Pelonomus*; metasternum less than twice as broad as long, with complete longitudinal suture and transverse suture bending back on each side to meet the edge of the coxal cavity as in BUPRESTIDAE; hind coxae separated by nearly a third the width of the sternum; furca with a short stalk and a large triangular "head," ventral median flange projecting in front of the apex of the triangle, the ventral process below the base of the triangle

and continuous in the middle with the flange of the sternal suture, no posterior sclerotisation, anterior tendons separated; furca small, half as long as sternum.

39. *Elmis maugeti* Bed. (Fam. Dryopidae or Elmidae). (Pl. 5 fig. 38.)

Insect much smaller than *Potamodytes*, of broader form; metasternum relatively broader, transverse suture closer to hind margin, straight, hind coxae separated as in the last, furcisternum between them with a deep emargination; furca similar to the last but much broader and little more than a quarter the length of the sternum.

39a. *Gyrelmis thoracica* Hint. (Fam. Dryopidae or Elmidae). (Pl. 5 fig. 39.)

Size and form resembling *Elmis*. Metasternum more than twice as broad as long, transverse suture not evident, longitudinal suture extending half the length of the sternum. Furca roughly Y-shaped, well sclerotised, about three-quarters as long as the sternum, ventral process as figured, anterior tendons not seen. *Xenelmis* sp., in size similar to *Elmis* and *Gyrelmis*, has a furca intermediate between them.

40. *Lutrochus gigas* Hint. (Fam. Dryopidae or Limnichidae). (Pl. 5 fig. 41.)

Form of a rather elongate and less convex *Byrrhus*; the metasternum is nearly four times as wide as long, with both sutures complete, the sternal suture being straight and the hind coxae practically contiguous; furca resembling *Psephenus* and *Ptilodactyla* in shape, posterior sclerotisation not evident, ventral process connected with the flange of the sternal suture.

41. *Limnichus pygmaeus* Stm. (Fam. Byrrhidae or Limnichidae). (Pl. 5 fig. 42.)

Form similar to last but much smaller; metasternum relatively less short, sutures as in *Lutrochus*, flange of sternal suture similarly wide, hind coxae slightly separated; furca with well-developed stalk, " head " very broad and short, anterior tendons widely separated, ventral process as in *Pelonomus*.

42. *Byrrhinus* sp. (Fam. Byrrhidae or Limnichidae). (Pl. 5 fig. 40.)

Size and form resembling *Ptilodactyla*; metasternum relatively shorter than in that genus, longitudinal suture nearly complete, transverse suture straight, complete, rather close to hind margin; furca in form resembling *Cyphon* but ventral process as in *Sostea*, posterior sclerotisation apparently present. Apart from the lack of the Helodid " ear " the ventral process resembles *Macrohelodes*.

43. *Cytilus sericeus* Forst. (Fam. Byrrhidae). (Pl. 6 fig. 44.)

A little smaller than *Byrrhus* but otherwise very similar; furca differing from that of *Byrrhus* in the ventral process, the lateral parts of which are distinctly posterior to the lateral arms, in the emargination of the front edge of the furca, and in the presence of what appears to be a weak posterior sclerotisation. As in *Byrrhus*, the sternal suture is obsolete and the longitudinal one is complete. *Microchaetes* differs from both *Byrrhus* and *Cytilus* in having a narrower and almost parallel-sided stalk, a distinct sternal suture (in both characters and in the presence of a distinct narrow clypeus resembling *Syncalypta*) and in the peculiar modification of the insertion of the anterior tendons which resembles *Derodontus*. Cf. 7, pl. 7 fig. 10.

44. *Laricobius erichsoni* Rosenh. (Fam. Derodontidae). (Pl. 6 fig. 45.)

A small insect, in form not unlike a *Cryptophagus*. Metasternum wider than long, longitudinal suture complete, sternal suture imperfect, close to hind margin; furca about half as long as sternum, lightly sclerotised, with a short broad stalk, antero-lateral arms present and broadened at their ends, median projection well marked, bearing slightly separated anterior tendons; ventral process large, situated posterior to the furcal arms, lateral corners projecting beyond the stalk on each side.

45. *Derodontus macularis* Fuss. (Fam. Derodontidae). (Pl. 6 fig. 46.)

Form slightly more elongate than the preceding; metasternum of similar form but with the sternal suture practically obsolete; furca with shorter stalk, thinner, more forward-curving arms, median projection deeply emarginate between the anterior tendons; ventral process apparently represented by a pair of obliquely placed lobes, situated under the median projection; posterior sclerotisation apparently absent as in the last.

46. *Ptosima flavoguttata* Ill. (Fam. Buprestidae). (Pl. 6 fig. 47.)

In this species the metasternum is about twice as broad as it is long, with a complete longitudinal suture and a transverse one that curves backward on each side to meet the coxal cavity as in *Potamodytes*. Furca small, about half as long as sternum, outline roughly pear-shaped, stalk short with narrow base, front margin straight between the separated anterior tendons; ventral process apparently represented by a pair of obliquely-placed lobes under the head of the furca and slanting in a postero-lateral direction (as do similar structures in *Ethon* and *Agrilus*, but in *Sphenoptera* they slope inward behind) or possibly by a ventral flange round the front margin of the furca which appears to connect in the middle with the flange of the sternal suture. In *Ptosima* the hind coxae are somewhat prolonged anteriorly at their inner edge, as also in *Sphenoptera*; in *Ethon* and *Agrilus* this character resembles the coxal process of Carabidae. Cf. 7, pl. 7 fig. 9.

47. *Nematodes* sp. (Fam. Eucnemidae). (Pl. 6 fig. 48.)

The metasternum is almost as long as wide, the longitudinal suture is weak and the sternal suture absent; furca three quarters as long as sternum, weakly sclerotised, shape resembling *Eulichas*, but posterior sclerotisation weaker (cf. *Ptosima*), ventral process represented by two small transversely-placed flaps well in front of the widest part of the furca. In *Melasis* the furca is much shorter and the flaps of the ventral process meet in the middle line.

48. *Denticollis linearis* L. (Fam. Elateridae). (Pl. 6 fig. 49.)

In form somewhat like *Athous* but more slender and with softer integument. The metasternum is wider than long, with the longitudinal suture nearly complete but no sternal suture. Furca with a long stalk, weakly sclerotised, median projection short, anterior tendons close, ventral process much as in *Artematopus*, but well behind the broadest part of the furca. This furca resembles that of *Cantharis* but the latter has no distinguishable ventral process. Cf. 7, pl. 7 fig. 5.

49. *Athous haemorrhoidalis* F. (Fam. Elateridae).

Metasternum and furca resembling the last, but anterior tendons slightly more separated, and ventral process with its lateral ends extending forward on each side as far as the widest part of the furca (as in all Elaterids studied except apparently *Denticollis*).

50. *Cardiophorus asellus* Er. (Fam. Elateridae).

Metasternum similar to the last; furca relatively shorter with "head" broader and anterior tendons more separated, ventral process with central part differentiated from the lateral parts as in *Agriotes*—in my figure of which (7) the differentiated part is all that is shown of the ventral process, the lateral parts being overlooked.

51. *Brachylacon murinus* L. (Fam. Elateridae).

This insect is of broader form than the preceding three. Metasternum more transverse than *Cardiophorus*, furca in shape resembling *Athous* but shortened, central part of ventral process differentiated as in the last species and *Agriotes*, but not as far behind the "head" of the furca as in either of them; anterior tendons separated about as in *Cardiophorus*.

52. *Prosternon holosericeus* Ol. (Fam. Elateridae). (Pl. 6 fig. 50.)

In form similar to *Agriotes*, the metasternum much as in *Cardiophorus*; furca with some resemblance to the latter but has well-developed lateral arms (in *Cardiophorus* they are incipient) and the ventral process has the middle part drawn forward on each side towards the middle line much as in *Callirhipis*, and is drawn out into postero-lateral processes on each side.

53. *Corymbites cupreus* F. (Fam. Elateridae).

In form similar to *Prosternon* (which has been classed in this genus) but larger; furca with similar but weaker lateral arms, ventral process normal and much as in *Athous*.

54. *Lampyris noctiluca* L. (Fam. Lampyridae or Cantharidae). (Pl. 6 fig. 52.)

The male of this familiar "Glow-worm" is of elongate form similar to *Cantharis* (*Telephorus*); as in that genus the metasternum is almost as long as wide, but the longitudinal suture is only about a third its length (two-thirds in *Cantharis*); the furca has a shorter and much wider stalk than in *Cantharis*, the median projection is relatively larger, and the ventral process rather like *Denticollis* but with no apparent forward prolongations at the sides.

55. *Lycus trabeatus* Guér. (Fam. Lycidae or Cantharidae). (7, pl. 7 fig. 7.)

In form similar to the last; metasternum with longitudinal suture almost complete; furca shorter than *Lampyris*, stalk broader (hind coxae separated), ventral process with central part similar to *Lampyris* but narrow lateral parts present as in *Brachylacon* and other Elaterids.

56. *Drilus flavescens* Geof. (Fam. Drilidae or Cantharidae). (Pl. 6 fig. 51.)

Smaller than the preceding two, but of similar form; metasternum and furca resembling *Lampyris*, but ventral process only doubtfully represented by a very small ridge.

57. *Nosodendron hispidum* Champ. (Fam. Nosodendridae or Byrrhidae). (Pl. 7 fig. 53.)

A convex insect with the appearance of a rather parallel-sided *Byrrhus*. Metasternum more than twice as broad as long, longitudinal suture extending three-quarters of its length, sternal suture not present. Furca about three-quarters as long as sternum, stalk short and rather wide, lateral arms long and well sclerotised, median projection represented by small projections on each side bearing the anterior tendons, the latter well separated and the space between them semi-circularly excavated, ventral process in the middle under the posterior margin of this excavation, extending under the arms at the sides, the lateral parts drawn out into large postero-ventral lobes; posterior sclerotisation apparently present.

58. *Orphilus niger* Rossi (Fam. Dermestidae). (Pl. 7 fig. 54.)

Body form like a small *Byrrhus*, metasternum similar to *Nosodendron*. Furca large and well sclerotised, nearly as long as sternum; stalk tapered towards base, lateral arms long and strongly sclerotised, median projection large and broad, bearing the separated anterior tendons, posterior sclerotisation well marked and typical, ventral process extending on each side under the base of the arms, lateral parts on each side with a well-marked muscle-disc. The furca of *Dermestes murinus* L. very much resembles this type, but has the arms rather shorter and the projections of the posterior sclerotisation to the anterior tendons close to the sides of the median projection. *Anthrenus* has the arms turned forward at an angle of about 30 degrees to the lateral and the median projection angularly excavate in the middle but is otherwise similar. *Trogoderma* has a furca which differs from *Orphilus* only in its shorter and broader form. *Attagenus* apparently differs from the other Dermestids in having less well-developed muscle-discs on the lateral parts of the ventral process. Cf. 7, pl. 8 fig. 6.

59. *Lasioderma serricorne* F. (Fam. Anobiidae). (Pl. 7 fig. 55.)

A small ovate insect, in shape resembling *Trogoderma*. Metasternum fully four times as wide as long, without evident sutures. Furca with a broad stalk, wide lateral arms (spanning more than half the width of the sternum), median projection very short, broad, ventral process with muscle-discs similar to those of *Trogoderma*. In *Sitodrepa* the stalk is evanescent and the arms turned forward, the muscle-discs being apparently absent (as in *Anobium*). There are no signs of muscle-discs in other Bostrychoid beetles I have examined. Cf. 7, pl. 8 fig. 8.

60. *Hendecatomus reticulatus* Hbst. (Fam. Bostrychidae or Cioidae). (Pl. 7 fig. 59.)

Form resembling *Cis boleti* but larger. Metasternum twice as broad as long, longitudinal suture extending half its length, sternal suture absent. Furca with a strongly sclerotised stalk, the furcal arms pointing antero-dorso-laterally and spanning three-quarters the width of the sternum, median projection small and deeply excavate in front, anterior tendons separated, ventral process strong, extending under the arms on each side and drawn backwards in the middle line under the stalk. Closely resembles *Dinoderus* (32, 34), with no likeness to Cioidae. Cf. 7, pl. 8 fig. 7.

61. *Psoa viennense* Hbst. (Fam. Bostrychidae or Psoidae). (Pl. 7 fig. 57.)

An elongate soft-bodied insect resembling *Hylecoetes* in shape. Metasternum as long as wide, with the longitudinal suture incomplete. Furca nearly as long as the sternum; stalk long, narrow, furcal arms curved and projecting antero-dorso-laterally, median projection as wide as stalk and half as long, anterior tendons close, ventral process apparently as in *Hendecatomus*, furcal arms near their ends with peculiar downward-projecting flaps. Differs from *Lyctus* chiefly in these flaps and in the long stalk. Cf. 7, pl. 8 fig. 9.

62. *Ptilinus pectinicornis* L. (Fam. Anobiidae). (Pl. 7 fig. 56.)

A cylindrical, rather elongate form about half as long as *Psoa*. Metasternum almost as long as wide, longitudinal suture extending half its length. Furca somewhat like *Psoa*, but stalk short and wide, arms not pointing so far forward, median projection more markedly widened out at the base; flaps under the furcal arms much as in *Psoa*. Cf. 7, pl. 8 fig. 8.

63. *Ptinus fur* L. (Fam. Ptinidae).

The female of this familiar species has the posterior part of the body rather broadly ovate; metasternum more than twice as broad as long with no distinct suture. Furca similar to that of *Lasioderma*, but the arms curving distinctly forward and no muscle-discs on the lateral parts of the ventral process.

64. *Tillus elongatus* L. (Fam. Cleridae). (Pl. 7 fig. 58.)

Much like *Psoa* in shape and in the metasternum. Furca with shorter stalk and longer arms than in *Psoa*, ventral process apparently represented by a peculiarly shaped structure which, postero-laterally on each side, appears to extend under the furcal arms, but in front it is attached to the sides of the median projection. This structure is probably homologous with a similar but larger one in *Hectarthrum*, but in the latter genus it seems to join on to the base of the furcal arms in the same way that the lateral parts of the ventral process do in normal Cleridae and Ostomidae. *Hectarthrum* is peculiar in that the ventral flange of the furca is continuous throughout its length with the flange of the longitudinal suture of the metasternum, thus forming a triangular plate the front edge of which forms a straight line from the front of the median projection to the front end of the longitudinal suture. In *Tillus*, as in normal beetles, these two flanges part company close to the base of the furca—in beetles with a sternal suture the lower edge of the ventral flange of the furca runs almost in a straight line in the direction of the point of intersection of the two sternal sutures until it meets the longitudinal flange of the sternum (e.g. in *Cupes*, Carabidae, Buprestidae, Dryopidae, etc.). Cf. 7, pl. 3 fig. 7, pl. 4 fig. 5.

65. *Corynetes coeruleus* Deg. (Fam. Cleridae or Corynetidae). (Pl. 8 fig. 61.)

A moderate-sized rather parallel-sided insect. Metasternum twice as wide as long, longitudinal suture extending less than half its length, hind coxae slightly separated. Furca weakly sclerotised, nearly as long as the sternum; stalk rather broad, furcal arms projecting antero-dorso-laterally, median projection broad and short, anterior tendons rather widely separated, ventral process with the ventral margin of the central part drawn far back in the middle line, lateral portions strongly marked, in front joining on to the exterior basal angles of the median projection, continuous behind with the median part. In an

Australian Clerid very like the European *Cylidrus* (*Denops*) the furca is very like that of *Hylecoetes* (LYMEXYLONIDAE). Cf. 7, pl. 1 fig. 1, pl. 4 fig. 5.

66. *Thymalus limbatus* F. (Fam. OSTOMIDAE). (7, pl. 4 fig. 2.)

The figure of the furca of this species in my earlier paper (7) is incorrect, in that *Thymalus* has the lateral parts of the ventral process (" Lamina " of my earlier paper) well developed in the form of postero-latero ventral flaps under the bases of the arms, intermediate in structure between the corresponding structures in *Attagenus* and *Leperina*.

67. *Danacaea pallipes* Pz. (Fam. MELYRIDAE or DASYTIDAE). (Pl. 8 fig. 62.)

Smaller and of shorter form than *Dasytes aerosus*; metasternum nearly as long as wide, with the longitudinal suture nearly complete, sternal suture absent. Furca with a narrow stalk and long arms pointing more anteriorly than laterally, ventral process with lateral parts developed as in *Dasytes* (7, pl. 4 fig. 4), median projection absent, anterior tendons widely separated and situated on the arms, ventral median flange projecting in front of the rest of the furca in the middle line (as in *Dasytes*, *Malachius*, *Melyris*, *Balanophorus* etc.).

68. *Phloeophilus edwardsi* Steph. (Fam. MELYRIDAE ?). (Pl. 8 fig. 63.)

Of broader, more ovate form than the last; metasternum nearly twice as wide as long, hind coxae almost contiguous, longitudinal suture extending more than half the length of the sternum. Furca with stalk broader than in the last, tapered to base, arms shorter and directed more laterally, median projection broad, short and emarginate between the separated anterior tendons, posterior sclerotisation well marked, lateral parts of ventral process narrow and prolonged, not continuous with the sides of the median projection. This furca is very like those of *Diphyllus* (7, pl. 3 fig. 11) and *Diplocoelus*, but in the latter two forms the lateral parts of the ventral process are continuous with the sides of the median projection in front and the stalk does not taper.

69. *Carpophilus hemipterus* L. (Fam. NITIDULIDAE).

Small, flattened, oblong, elytra abbreviated; metasternum twice as broad as long with complete longitudinal suture. Furca similar to *Omosita* (7, pl. 3 fig. 9) but arms directed laterally; lateral parts of ventral process, as in *Omosita*, not visibly developed.

70. *Brachypterus urticae* F. (Fam. NITIDULIDAE). (Pl. 8 fig. 65.)

Smaller than the last, longitudinal suture only extending half the length of the metasternum. Furca short, with long and strong antero-lateral arms, median projection short with straight sides meeting at an obtuse angle in front, anterior tendons moderately separated, ventral process with lateral parts not visibly differentiated.

71. *Meligethes lumbaris* Stm. (Fam. NITIDULIDAE).

Metasternum more than twice as wide as long, longitudinal suture obsolete. Furca very short, median projection short, broad, emarginate between the well-separated anterior tendons, lateral parts of the ventral process farther from the middle line than in other NITIDULIDAE and under the furcal arms.

72. *Nitidula bipunctata* F. (Fam. Nitidulidae). (Pl. 8 fig. 64.)

Of typical Nitidulid form, small, short, flattened, rectangular. Metasternum twice as broad as long, longitudinal suture complete, sternal suture absent. Furca with a broad short stalk, a quarter as wide as the sternum; furcal arms directed antero-dorso-laterally and spanning more than half the width of the sternum; median projection large, half as wide as the stalk in front, with a distinct posterior sclerotisation; central part of the ventral process forming a narrow bar across the middle of the furca, lateral parts drawn out antero-laterally on each side; upper anterior edge not continuous with the sides of the median projection. This may be taken as the typical furca of the family; *Prometopia* and *Soronia* are very similar, but with the median projection shortened, while *Cychramus* has the lateral parts of the ventral process reduced; *Glischrochilus* has the median projection short and rather emarginate between the anterior tendons, the ventral process is similar to *Hyliota*. Cf. 7, pl. 3 figs. 5, 9, 10.

73. *Holoparamecus caularum* Aub. (Fam. Lathridiidae). (Pl. 8 fig. 66.)

Very small, rather parallel-sided; metasternum wider than long, longitudinal suture complete. Furca with very short stalk, somewhat resembling *Brachypterus* but without the strongly developed arms of the latter; lateral parts of ventral process apparently not differentiated; bases of anterior tendons strongly marked, connected together as in *Hyliota*. Cf. 7, pl. 3 figs. 5, 2.

74. *Eufalloides holmesi* Hint. (Fam. Lathridiidae).

Size and shape similar to the last; metasternum more than twice as wide as long, longitudinal suture absent, hind coxae widely separated. Furca consisting of a pair of widely diverging arms arising from the inner articulation of the coxae. In *Adistemia watsoni* Woll. the hind coxae are more widely separated and the furcal arms are strongly curved; in *Coninomus nodifer* West. the bases of the arms are connected by a transverse ridge; *Enicmus minutus* L. and *Cartodere* sp. resemble *Eufalloides*. In all Lathridiid furcae examined except *Holoparamecus* the anterior tendons are widely separated and on the arms.

75. *Thorictus grandicollis* Germ. (Fam. Thorictidae). (Pl. 8 fig. 68.)

A small, oblong apterous insect with very short metasternum and small, contiguous hind coxae. Furca without a distinct stalk, shaped like a wide V; anterior tendons widely separated, short and broad; ends of the arms of the " V " with short furcal arms and a well-marked lamina. Possibly derived from something like the furca of *Byturus*.

76. *Sphindus dubius* Gyll. (Fam. Sphindidae). (Pl. 8 fig. 67.)

Shape like a small *Cis*; metasternum twice as broad as long, longitudinal suture nearly complete. Furca resembling *Rhizophagus*, but stalk rather wider, lateral parts of ventral process narrower, furca slightly produced in the middle as in Cryptophagidae or *Holoparamecus*. Cf. 7, pl. 2 fig. 9.

77. *Xylographus bostrichoides* Duf. (Fam. Cioidae). (Pl. 7 fig. 60.)

Size and shape similar to the last, metasternum twice as broad as long, without sutures (as in *Ennearthron*; *Cis boleti* has a longitudinal suture extend-

ing half the length of the sternum). Furca as in other CIOIDAE, a pair of widely diverging arms with widely separated anterior tendons. Cf. 7, pl. 8 fig. 11.

78. *Pterogenius nietneri* Cand. (Fam. CIOIDAE ?). (Pl. 9 fig. 76.)

Form similar to a *Cis*; metasternum more than three times as broad as long, longitudinal suture nearly complete. Furca with short stalk, long antero-lateral arms, widely separated anterior tendons, lateral parts of the ventral process undifferentiated. Exactly like the furcae of specialised TENEBRIONIDAE *e.g.* DIAPERINAE. See 6.

79. *Byturus tomentosus* F. (Fam. BYTURIDAE). (Pl. 9 fig. 69.)

A familiar British species of long ovate form; metasternum twice as broad as long with nearly complete longitudinal suture. Furca with stalk rather short and broad, arms rather short and pointing a little in front of dorso-laterally, lateral parts of the ventral process forming a well-marked lamina, much as in *Triplax* (7, pl. 2 fig. 4), the antero-external borders of the lamina being continuous with the front edge of the furca, anterior tendons separated less than in *Triplax* but more than in *Cryptophagus*.

80. *Orthoperus* sp. (Fam. CORYLOPHIDAE). (Pl. 9 fig. 70.)

Very small, convex, ovate; metasternum more than twice as wide as long, hind coxae separated by more than half width of sternum. Furca consisting of a pair of arms arising at the inner ends of the hind coxae and bearing the widely separated anterior tendons.

81. *Murmidius ovalis* Beck. (Fam. COLYDIIDAE or MURMIDIIDAE). (Pl. 9 fig. 73.)

Very small, ovate, rather flattened, metasternum twice as wide as long, with complete longitudinal suture (in *Cerylon* not much wider than long and without longitudinal suture), hind coxae separated by half the width of the sternum. Furca consisting of a pair of long somewhat curved arms connected across their bases by a narrow bar, lateral parts of the ventral process apparently represented by a small ventral flap about half-way up each arm, anterior tendons not certainly distinguishable in my preparation. Cf. 7, pl. 3 fig. 4.

82. *Myrmecoxenus vaporariorum* Guér. (Fam. COLYDIIDAE ?). (Pl. 9 fig. 72.)

Form resembling a small *Cryptophagus*; metasternum more than twice as broad as long, longitudinal suture extending a third of its length. Furca with stalk very short and tapered to the base, with strong antero-dorso-lateral arms, lateral parts of the ventral process represented by postero-ventral flaps near the ends of the arms, anterior tendons widely separated, arising opposite the points of attachment of the lateral parts of the ventral process. This much resembles the *Tribolium* furca, also *Ditoma* (7, pl. 2 fig. 1; pl. 2 fig. 7).

83. *Enarsus bakewelli* Pasc. (Fam. COLYDIIDAE). (Pl. 9 fig. 74.)

Form rather broad, resembling a Nitidulid; metasternum fully three times as broad as long, with a longitudinal suture extending two-thirds of its length and a peculiar line, stretching antero-laterally on each side from near the middle of the hind margin of the furca and dividing off a narrow triangle of the sternum behind it on each side—this part of the sternum is differently sculptured from

the rest. Furca large, with a short broad stalk, sinuate lateral arms, widely separated anterior tendons, the lateral parts of the ventral process represented by narrow lobes much as in some Tenebrionids (*Derosphaera*—7, pl. 1 fig. 8). In *Orthocerus clavicornis* the metasternum has a line across it as in *Enarsus* and the furca is intermediate between the latter genus and *Ditoma*.

84. *Anommatus duodecemstriatus* Wesm. (Fam. Colydiidae or Lathridiidae).

Very small, elongate and parallel-sided; metasternum more than twice as broad as long. Furca similar to the last but rather shorter and with the lateral parts of the ventral process apparently not differentiated. The line across the metasternum appears to be weak or absent. See 18.

85. *Georyssus pygmaeus* F. (Fam. Georyssidae). (Pl. 9 fig. 75.)

Small form resembling a short *Elmis*; metasternum about four times as wide as long, longitudinal suture nearly complete (very short in *Anommatus*), the line across it well marked and simulating a transverse suture. Furca similar to *Enarsus* but more shortened and stalk broader.

86. *Othnius kraatzi* Reitt. (Fam. Othniidae). (Pl. 9 fig. 71.)

Form resembling a small *Mycetophagus*; metasternum less than twice as broad as long, longitudinal suture very short. Furca rather like that of *Myrmecoxenus* but stalk longer and narrower and lateral parts of the ventral process better developed; it also much resembles *Mycetophagus*, but in the latter the anterior tendons are not quite as widely separated and the lateral parts of the ventral process are reduced. Cf. 7, pl. 1 figs. 3–11; pl. 2 figs. 1, 6.

87. *Hypophloeus bicolor* Ol. (Fam. Tenebrionidae). (Pl. 9 fig. 77.)

Form similar to *Rhizophagus*; metasternum wider than long, longitudinal suture extending half its length. Furca Y-shaped with very short stalk, anterior tendons close to ends of arms, "lamina" absent. In *Uloma* the metasternum is relatively wider, the longitudinal suture longer, and the furcal arms directed more laterally than anteriorly. In the wingless *Blaps* the metasternum is very short, with no longitudinal suture, and the furca is V-shaped with no stalk. The Australian *Adelium*—also wingless—has a similar metasternum but the furca has a stalk. In the common British *Helops striatus* the furca is very like that of *Derosphaera* (7, pl. 1 fig. 8).

88. *Carpophagus banksiae* Mcl. (Fam. Chrysomelidae). (Pl. 10 fig. 78.)

A large species, in shape resembling a *Sagra*; metasternum nearly four times wider than long, with complete longitudinal suture (as in *Sagra*, and *Mecynodera*). Furca very like that of *Sagra*, stalk rather short, arms pointing nearly laterally, lateral parts of the ventral process drawn out into long lobes, anterior tendons less widely separated than in *Sagra*. Cf. 7, pl. 5 figs. 1, 6.

89. *Mastostethus* sp. (Fam. Chrysomelidae). (Pl. 10 fig. 79.)

Form resembling the preceding but smaller; metasternum similar to the preceding, furca with longer and narrower stalk, arms longer and projecting slightly backward, anterior tendons separated about as in *Carpophagus*, less than in *Mecynodera* (which this furca otherwise very closely resembles).

90. *Megascelis viridis* Ill. (Fam. Chrysomelidae). (Pl. 10 fig. 80.)

A moderate-sized rather narrow-bodied form; metasternum twice as broad as long, with a complete longitudinal suture (as in all Camptosomata that I have seen). Furca with a long stalk (two-thirds as long as the sternum), widely diverging arms, and an obtuse median projection bearing rather close anterior tendons. Lateral parts of ventral process not developed (as in all Camptosomata seen except *Lamprosoma*). The remaining Camptosomatan forms studied (*Clytra*, *Labidostomis*, *Cadmus*, *Chlamys*, *Cryptocephalus*) all differ in having the median projection much narrower than in *Megascelis*. I believe that the median projection of Camptosomata is a secondary development and therefore not homologous with that of Bostrychoidea, and on this view the condition in *Megascelis* might be ancestral to the other Camptosome furcae, and itself presumably derived from a Eupodan type. Cf. 7, pl. 5 figs. 3, 9.

91. *Caryoborus rubidus* Chevr. (Fam. Bruchidae). (Pl. 10 fig. 85.)

Form resembling *Carpophagus* but of about half its dimensions; metasternum about three times as wide as long, longitudinal suture almost complete (obsolete in *Bruchidius*). Furca with short stalk and strong, widely diverging slightly curved arms, lateral parts of ventral process not developed, anterior tendons very widely separated (they are much closer in *Bruchidius*). Cf. 7, pl. 6 fig. 7.

92. *Platyrrhinus resinosus* Scop. (Fam. Anthribidae). (Pl. 10 fig. 82.)

Rather large, parallel-sided and somewhat short; metasternum four times as wide as long, longitudinal suture complete (as in *Araecerus* and *Brodon*). Sternal suture also present. Furca with short stalk, wide lateral arms curving forward at their ends, anterior tendons contiguous, lateral parts of the ventral process small but distinct as in *Araecerus* and *Urodon*. General appearance of furca very like *Urodon* but rather more shortened. Cf. 7, pl. 7 figs. 3, 4.

93. *Mecinus pyraster* Hbst. (Fam. Curculionidae). (Pl. 10 fig. 83.)

Small, rather elongate and parallel-sided; metasternum nearly four times as wide as long, longitudinal suture extending a third of its length. Furca with fairly long stalk, long antero-lateral arms, lateral parts of ventral process well marked, anterior tendons moderately separated. Differs from the *Anthonomus* furca (7, pl. 6 fig. 11) chiefly in the longer and narrower stalk and the longitudinal suture of the metasternum. Of the Curculionidae examined by me, *Cimberis* (*Rhinomacer*), *Belus*, *Rhynchites*, *Apion*, *Nanophyes*, *Brachycerus*, *Mecinus*, also *Cordus* (Brenthidae), have furcae with a distinct narrow stalk; in *Apoderus* the stalk is shorter but still narrow, in *Cylas* narrow and very short, in *Orchestes*, *Orobitis*, *Pissodes*, *Calandra*, *Cionus*, *Sciaphilus*, *Balaninus*, *Polychlaeis* etc., more or less as in *Baris* (pl. 10 fig. 84). All Curculionidae studied (not Brenthidae) have the anterior tendons more or less separated, they are closest in *Belus*, *Rhynchites*, *Apoderus*, *Apion*, *Nanophyes* (in this genus they are borne on a distinct median projection), *Anthonomus* and *Calandra*, farther apart in the remaining genera. The lateral parts of the ventral process are best developed in *Rhynchites*, *Belus*, *Mecinus*, *Brachycerus*, apparently absent in *Apion*, and more or less reduced in the remaining forms. Cf. 7, pl. 6 figs. 8–12.

IV. Phylogenetic Discussion.

Ever since the theory of Organic Evolution became generally accepted, taxonomists have striven to devise classifications that will reflect the phylogeny of the forms concerned. In some groups of animals—*e.g.* Mammals, Trilobites, the Panorpoid complex among Insecta—it is possible on the basis of fossils alone to arrive at the broad outlines of the descent of the animals, but such fossils as are at present known of the Coleoptera afford very little help in this way. Theories of the phylogeny of beetles can thus only be based on the comparative structure of modern forms—*i.e.* on the same data as are used in ordinary classification. In practice, of course, the taxonomists have of necessity concentrated their attention on the external characters of the adult insect, while those who have speculated concerning phylogeny have generally based their conclusions on such things as internal anatomy and larval structure which are not used in ordinary systematics. I do not accept the implication that a character that is difficult to observe must therefore be of greater phylogenetic importance than an easily observed one. In fact, more reliance ought to be placed on the ordinary taxonomic characters, since they have been tested and confirmed on a far greater number of forms than have most of the more obscure characters. Thus I would not suggest that the furca is in itself of greater phylogenetic value than, for example, the structure of the tarsi (which some recent workers have despised unduly). I shall endeavour to interpret the relationships of the forms studied, not from the structure of the furcae alone (which would frequently lead to absurd conclusions), but from the furcae considered in relation to such other characters as are known to me. As my knowledge of the comparative morphology of Coleoptera is very limited, and the furcae of only about four hundred and fifty genera out of many thousands have been examined, it is fairly certain that many of my deductions will prove to be wrong! In view of the shortcomings and errors of my earlier paper it will be necessary to go over much ground again in this paper. In presenting my conclusions I shall start by considering the most specialised forms (Curculionidae) and try to work backwards to embrace forms progressively more distantly related to them.

For the relationships of the Curculionidae a valuable paper by van Emden (12) may serve as a basis. According to this author, the old group "Orthoceri" includes the more primitive weevils in larval as well as adult structure. Of the forms studied, *Rhinomacer*, *Rhynchites*, *Apoderus*, *Belus*, *Apion*, *Cylas* and perhaps *Nanophyes* have been included in Orthoceri. In van Emden's sense of the term, only *Rhynchites*, *Apoderus* and *Belus* of these are included. In them the furca has the anterior tendons only narrowly separated, a well-marked stalk, and broad lateral parts of the ventral process. No other weevil furca I have seen shows all three of these primitive characters together; those which show the first two are *Apion*, *Nanophyes* and *Mecinus*—of these *Apion* has the lateral part of the ventral process absent (also in *Cylas*), in *Nanophyes* it is very weak, while in *Mecinus* it is as in *Anthonomus*. Van Emden has a separate subfamily Apioninae which he places between Orthoceri and his Mecininae-group; he also cites *Nanophyes* as transitional from Apioninae to Mecininae, while *Cylas*, which in the furca appears as a specialised offshoot of *Apion*, is also noted as exceptional by him. His Mecininae-group includes *Mecinus*, *Rhynchaenus* (*Orchestes*), and *Orobitis* of the forms I have studied. The last two have specialised furcae much like ordinary Gonatocerous weevils, but it is quite possible that they are derived from *Mecinus*-like ancestors. In

fact, the furcal evidence is so far entirely reconcilable with van Emden's conclusions. The genus *Cimberis* (*Rhinomacer*), formerly included in Orthoceri, is excluded from the CURCULIONIDAE altogether by van Emden, and here again the evidence of the furca is in agreement, as in this genus we find the lateral parts of the ventral process more primitive than in any CURCULIONIDAE I have seen, but the anterior tendons widely separated. According to van Emden, the *Cimberis* larva can be referred to ANTHRIBIDAE, but here the structure of the furca is not in agreement. It is possible of course that among ANTHRIBIDAE (I have seen only three) a furca transitional to the *Cimberis* type may be discovered, but I think it unlikely. The ANTHRIBIDAE themselves have furcae more primitive than CURCULIONIDAE in having contiguous anterior tendons, but more specialised than *Cimberis* in the structure of the lateral part of the ventral process and in the reduced stalk. According to van Emden, *Urodon* belongs in the BRUCHIDAE, but the larval characters on which he bases this conclusion are all derivative and negative, and *Urodon* has not the essential *specialised* character which Böving gives for Bruchid larvae (*i.e.* mentum and submentum fused, with shield-like sclerome); as the *Urodon* furca is close to those of *Platyrrhinus* and *Araecerus* I think it possible to disagree with van Emden's conclusion (5, 52). The Rhynchophora may comprise six families: ANTHRIBIDAE, NEMONYCHIDAE, BRENTHIDAE, PROTERHINIDAE, CURCULIONIDAE, SCOLYTIDAE. Of these, NEMONYCHIDAE may have distinct gular sutures, they and ANTHRIBIDAE have a molar to the larval mandible, the latter family and BRENTHIDAE have close anterior tendons, the PROTERHINIDAE have a specialised pair of arms furca, but according to van Emden their larvae are close to the Curculionid *Belus*; it appears doubtful whether SCOLYTIDAE are naturally distinct from CURCULIONIDAE (I have not seen the furcae of *Crossotarsus* etc.). We can now proceed to consider the relationships of the Rhynchophora as a whole. The ancestral furca of the group must have been rather like the *Cimberis* type but with close anterior tendons as in *Cordus*. In addition to this, other characters of the primitive Rhynchophora must have been: Antennae filiform, tarsi pseudotetramerous, Malpighian tubules cryptonephridic (40), metasternum without sternal suture,[1] larva with a mandibular molar, one maxillary lobe,[2] abdominal terga with two folds, no urogomphi; wing-venation (16), aedeagus (46) and furca close to the Cerambycid–Chrysomelid type. There can be no doubt that the Rhynchophora are closely related to the CERAMBYCIDAE and CHRYSOMELIDAE, so I shall deal briefly with these two groups before considering the Phytophagous complex as a whole.

Cerambycid furcae appear always (except *Distenia*) to have a narrow stalk, the anterior tendons never contiguous (in PRIONINAE only slightly separated), lateral parts of ventral process strongly developed except in PRIONINAE and *Distenia*. The furcal arms are usually directed more or less laterally (as in *Belus*), but in PRIONINAE (except *Parandra*) they curve forward. The ancestral type would appear to be practically identical with that of Rhynchophora. The furca of *Spondylus* looks as though it might be close to the ancestral form of PRIONINAE, having the arms unusually long and curved forward; the lateral parts of the ventral process are well developed and the front margin of the furca distinctly emarginate as in *Tetropium* (ASEMINAE). Following Böving and Craighead, van Emden (13) puts all the Longicorn beetles in one family CERAMBYCIDAE with six subfamilies: PRIONINAE, CERAMBYCINAE, ASEMINAE, LEPTURINAE, LAMIINAE, DISTENIINAE. The structure of the furca would agree

[1] There appears to be a sternal suture in ANTHRIBIDAE, so this may be wrong.

[2] Unless the apparently two-lobed maxilla of ANTHRIBIDAE is primitive.

better with the older view that PRIONIDAE form a distinct family, and I think there is much to be said for giving *Distenia* family status (3, 16). If the PRIONIDAE are defined on the furca, *Parandra* would have to be excluded—but apparently its larva is a Prionid type (13). Of the CERAMBYCIDAE proper, I am inclined to think that ASEMINAE include the more primitive forms, especially if *Spondylus* is included, but the only Asemine furca I have seen (*Tetropium*) does not appear particularly primitive. Larvae of CERAMBYCIDAE appear never to possess a mandibular molar, but some (ASEMINAE) have urogomphi (13).

The furcae of CHRYSOMELIDAE are very diverse, and the only statement which will apply to all that I have seen is that the anterior tendons are never contiguous. The divisions Eupoda, Camptosomata, Trichostomata, Cyclica and Cryptostomata are used by Jacoby (27). If we set aside a few exceptional forms, these divisions are easily recognised in the furcae. The Eupoda always have a stalk and the lateral parts of the ventral process are always developed, the Camptosomata also have a stalk, but the lateral parts of the ventral process are not developed and there is always a median projection,[3] the Trichostomes have the stalk but no median projection and the lateral parts of the ventral process absent, Cyclica have a pair of arms furca with widely separated anterior tendons, while the Cryptostome furca resembles Eupoda but is shorter and has the lateral parts of the ventral process less developed. The exceptional forms mentioned are *Lamprosoma*, *Colasposoma* (subfamily EUMOLPINAE), and *Mastostethus*; the first has been included in Cyclica, but the larva (3) is apparently Camptosomatan; *Colasposoma* has usually been put in the Cyclica, while *Mastostethus* was included by Jacoby in Camptosomata. The *Lamprosoma* furca is the only one I have seen outside Eupoda and Cryptostomes that has the lateral parts of the ventral process distinctly developed; the *Colasposoma* furca (pl. 10 fig. 86) differs from any Chrysomeline furca I have seen (*Timarcha*, *Prasocuris*, *Hydrothassa*, *Phytodecta*, *Phaedon*, *Australica*) in having a short narrow stalk, thus it resembles Trichostomes; the *Mastostethus* furca is typically Eupodan. The primitive Chrysomelid furca would be a Eupodan type resembling that of *Orsodacne* but with rather closer anterior tendons as in *Carpophagus*. This would be almost identical with the ancestral Rhynchophoran and Cerambycid types. Chrysomelid larvae lack the primitive features of a mandibular molar and urogomphi, and it might be surmised that the CHRYSOMELIDAE originated rather later than Rhynchophora and CERAMBYCIDAE, probably from a Cerambycid ancestor. In support of this it is noteworthy that primitive Rhynchophoran and Cerambycid forms tend to feed on Gymnosperms (*e.g.* NEMONYCHIDAE, ASEMINAE), a type of vegetation which was dominant in most of the Mesozoic era, while primitive Chrysomelid forms (*e.g.* ORSODACNINAE, SAGRINAE) always appear to feed on Angiosperms, which only arose at the very end of the Mesozoic (Cretaceous).

We can now consider the Phytophagous complex as a whole. The ancestral Phytophagous beetle may have existed in the Jurassic period; it would have had simple filiform antennae, paired gular sutures, more or less pseudotetramerous tarsi, wing-structure (17) and aedeagus (46) of Cucujoid type, cryptonephridic Malpighian tubules (40), furca as described for ancestral Rhynchophora, metasternum without sternal suture;[4] the larva would have had a mandibular molar, one maxillary lobe,[5] and urogomphi. If such a beetle existed today, it would certainly be classed in Cucujoidea, though not in any existing family. In support of this it is to be noted that, not only is the primitive Phytophagous

[3] Probably not homologous with the true median projection.
[4] See footnote 1. [5] See footnote 2.

furca typically lower Cucujoid, but most types of specialised Phytophagous furcae can be duplicated in one or other Cucujoid family, showing that the original Phytophagan furca possessed evolutionary potentialities similar to the Cucujoid type. As against this, Dr. Böving, in a letter, tells me that he believes that larvae of Phytophaga are derived from Byrrhoid ancestors. The chief characters he cites in favour of this are the absence of a mandibular molar in Phytophaga (and its presence in Cucujoidea), the absence of urogomphi, the presence of two maxillary lobes in many CHRYSOMELIDAE, and the presence of several teeth in the mandible of such forms as *Phyllobrotica*. The first of these characters is phylogenetically unsound, as some Phytophagous larvae have the molar and some Cucujoids lack it, and the same applies to the second character. Of the last two characters, neither is found in the forms which Böving himself puts at the beginning of CHRYSOMELIDAE, and his interpretation of the maxillary lobes is thus open to doubt.

Having traced the Phytophaga to a Cucujoid ancestor, we may now consider the Cucujoidea themselves. The first point that emerges is that, having given rise to the Phytophaga, the Cucujoidea must be older than that group. In accordance with this we find that Cucujoidea include far fewer species but far greater structural range than Phytophaga—a great number of the more primitive Cucujoid types must have become extinct, and as a result we find it difficult to unravel the relationships of the forms that remain.

The Cucujoidea, in my sense of the term, correspond to the Cucujoidea of Böving (3) without *Eucinetus* and DERODONTIDAE, but including MELOIDAE, RHIPIPHORIDAE and MORDELLIDAE. Thus it comprises the whole of the old group Heteromera, plus the true, typical Clavicornia. In view of the fact that almost all recent students have recognised the nearness of the connection between such Clavicorn families as EROTYLIDAE and LANGURIIDAE, and the Heteromera, it is hardly necessary for me to discuss the reasons for adopting this grouping. The TENEBRIONIDAE (with LAGRIIDAE and CISTELIDAE) are regarded by Böving (3) as possessing the most specialised larvae of the Cucujoidea; as they appear to be equally specialised in the structure of the furca, and form the only Cucujoid family that enjoys at the present day a success comparable with that of the great Phytophagous families, we may consider them first. Tenebrionid furcae resemble those of most Heteromera (and differ from most Clavicornia) in possessing a well-marked stalk, and in having widely separated anterior tendons. They differ from other Heteromera chiefly in the extreme modification and reduction of the lateral parts of the ventral process. My figure (7, pl. 1 fig. 8) of the *Derosphaera* furca may be taken as typical; in *Helops*, *Uloma*, and *Gnathocerus* the lateral parts of the ventral process are much as in *Derosphaera*, in the remaining forms studied (with *Pterogenius*, *Lyprops*, LAGRIIDAE and CISTELIDAE) they are practically obsolete. The most aberrant form I have seen is the *Tribolium* furca (7, pl. 2 fig. 1) in which the stalk is very short and the lateral parts of the ventral process are quite sharply differentiated, the furca thus resembling *Myrmecoxenus* and *Ditoma*. According to my criteria, this must mean either that *Tribolium* is not a Tenebrionid, or that its furca preserves a primitive character which has been lost in the rest of that family. The adult and larval characters of *Tribolium* do not support the first theory, so I will adopt the second. Thus for the ancestral Tenebrionid furca we must postulate a furca with the lateral parts of the ventral process at least as well marked as in *Tribolium*, with a distinct stalk, and probably with the anterior tendons arising at the junction of the lateral parts of the ventral process and the arms. This would be very close to the *Othnius* furca; in this connection we

may note that *Othnius* has been regarded as closest to TENEBRIONIDAE in adult structure (31, 49) and has been stated to differ from them chiefly in the more mobile abdominal sterna, that the family OTHNIIDAE is a small one with a primitive type of distribution (45), and that in Böving's larval classification OTHNIIDAE are placed immediately before the Tenebrionid group. It may plausibly be suggested that OTHNIIDAE are comparatively little modified descendants of a group ancestral to TENEBRIONIDAE. If we tentatively accept this hypothesis, the next problem that arises is the ancestry of *Othnius*. The *Othnius* furca does not differ profoundly from those of many other Heteromera, e.g. *Aegestria* (PEDILIDAE), *Pyrochroa*, *Melandrya* etc., but I have not studied enough Heteromerous furcae to be able to say which of them is closest to *Othnius*—it is quite likely, furthermore, that the relevant forms are extinct. On other characters, *e.g.* the larva (3) and the aedeagus (46), *Othnius* seems to be connected with PYTHIDAE and BORIDAE. Besides the Tenebrionid group, MYCETOPHAGIDAE and COLYDIIDAE have furcae which would seem to be derived from the Othniid type. Certain of the Heteromera, e.g. *Oedemera*, are apparently more primitive than the forms so far considered in having the anterior tendons closer together. Thus the ancestral Heteromeran furca must have been rather like LANGURIIDAE, though the beetle which possessed it must presumably have differed from LANGURIIDAE in having filiform antennae and simple five-jointed tarsi. According to Böving, Lymexylonid larvae are closest to OEDEMERIDAE, and in this connection it is notable that Forbes (16) remarked that the wing-venation of LYMEXYLONIDAE suggested the ancestor of the Heteromera, also that recently (39) a beetle has been described that is very like *Lymexylon* but has heteromerous tarsi. Our phylogenetic probing has now led us to somewhere near the base of the Cucujoid stem, and we have to deal with hypothetical ancestral forms, presumably long extinct, which must have differed radically from any existing types. For example, existing Lymexylonid larvae are highly modified for a wood-boring life, but in considering the LYMEXYLONIDAE as possible ancestors of Heteromera, we have to try to imagine what an ancestral Lymexylonid larva that was not so adapted would have been like—whether it might perhaps have been something like a Languriid larva? If one were to look for a furca intermediate between the LANGURIIDAE and the LYMEXYLONIDAE, the best approximations that I know are found, not in the Cucujoidea at all but in the Phytophaga, and I regard this as significant. The suggestion I put forward, then, may be outlined thus: the LYMEXYLONIDAE are a family of very ancient (possibly even Triassic) origin, that in the ancestral forms of the family the structure was not adapted for wood-boring and the larva had the characters which Böving regards as primitive in Cucujoidea. Existing LYMEXYLONIDAE have descended direct from this with modification—strong in the larva, weak in the adult—for a wood-boring life. From very similar forms with slightly more specialised furcae, at a slightly later date arose the ancestral Phytophagan, and also a Languriid–Heteromeran ancestor. From an early Languriid type EROTYLIDAE (42), COCCINELLIDAE, PHALACRIDAE, ENDOMYCHIDAE, perhaps CORYLOPHIDAE, and BYTURIDAE have descended—in all of these, as in LANGURIIDAE and Heteromera, the anterior tendons are separated. *Sphindus*,[6] *Rhizophagus*, and CRYPTOPHAGIDAE, which have close anterior tendons, may have had a slightly earlier origin. CUCUJIDAE (*Hyliota*) and NITIDULIDAE, with *Diphyllus* and *Diplocoelus* (but cf. 15), would, to judge by

[6] According to Stierlin (48), *Sphindus* has heteromerous tarsi in the male sex. The aedeagus is evidently cucujoid (46) as is the larva; the wing folding is, however, anomalous (17) and approaches Bostrychoidea.

the furca, seem to have had an even earlier origin, from an ancestor which possessed a better developed median projection than *Hylecoetes*; and LATHRIDIIDAE, if *Holoparamecus* is taken as near the primitive type (25), may have come from CUCUJIDAE. The CUCUJIDAE are evidently an ancient family, with a surprising diversity of furcal types—there are specialised pair of arms types (SILVANINAE, *Laemophloeus*), in *Hemipeplus* a furca near the Phalacrid–Erotylid type, in *Hyliota* a close approach to NITIDULIDAE, while *Hectarthrum* (PASSANDRINAE) has a furca very like those of CLERIDAE and very different from any other Cucujoid I have seen. If *Hectarthrum* is really a Cucujoid (cf. 46), then its furca must be the most primitive one of the group, and the CUCUJIDAE must be the oldest family of the Cucujoidea. It would then follow that the Cucujoids have arisen from Cleroid ancestors. This conclusion might have been arrived at even without considering *Hectarthrum*, if we took the *Hylecoetes* furca as the primitive Cucujoid type. For the chief distinction between Cucujoidea and Cleroidea in the furca is the normal absence in the former group of a median projection, and in *Hylecoetes* there is a distinct indication of the median projection. Moreover on the structure of the adults LYMEXYLONIDAE have nearly always been classed near CLERIDAE and MELYRIDAE. If the derivation of Cucujoidea from Cleroidea raises no particular difficulties as far as adult structure is concerned, it must be admitted that it is very hard to reconcile it with the structure of the larval mouthparts. Assuming, as I have done, that the presence of a mandibular molar is more primitive than its absence, we are faced with the difficulty that nearly all the more primitive Cucujoid larvae have the molar, while it is apparently entirely absent in Cleroidea. Now if my theory is correct, the Cleroidea as a group must be older than the Cucujoidea. But we do not find among existing Cleroidea a complicated jumble of small families and miscellaneous annectant forms such as compose the Cucujoidea. Existing Cleroidea fall into four well-defined, evidently specialised families—an analogous condition might arise if in some future geological period the Cucujoidea should come to be represented only by LATHRIDIIDAE, COCCINELLIDAE, MORDELLIDAE and TENEBRIONIDAE. All of these forms have larvae normally without urogomphi, yet the presence of urogomphi is one of the typical features of most present-day Cucujoid larvae. Similarly it is not impossible that the primitive Cleroid larvae had a mandibular molar despite its absence in present-day DERMESTIDAE, TROGOSITIDAE, CLERIDAE and MELYRIDAE. The other features of Cleroid larvae are not so difficult to reconcile with my theory—for instance the maxilla primitively has two lobes (DERMESTIDAE) but in the more specialised forms apparently only one—in Cucujoidea there is normally one lobe but in some forms (and also in ANTHRIBIDAE) there is some indication of a division into two; many Cleroid larvae have well-marked urogomphi, and in some of them spiracles resembling the biforous ones of primitive Cucujoid forms are found. The dorsal spinose plates which Böving regards as primitive in Cucujoid larvae may be homologous with those of DERMESTIDAE.

While the Hylecoetoid furca is found throughout the Cucujoidea and Phytophaga, and evidently characterised the ancestor of those groups, it is very doubtful whether the furca of the ancestral Cleroid was truly Hylecoetoid, and indeed on the data at my disposal it is hardly possible to reconstruct it with any degree of certainty. In the family MELYRIDAE the furca in *Malachius*, *Balanophorus* and *Melyris* lacks the lateral parts of the ventral process; this is an evidently specialised condition, and we may take the *Dasytes* furca as primitive for the family (cf. 41). In this the anterior tendons are rather narrowly separated and the ventral flange projects a little in front of the body of the

furca—a characteristic Melyrid feature which may be a vestige of the median projection. The *Danacaea* furca is evidently derived from this type by further separation of the anterior tendons; *Melyris* by the loss of the lateral parts of the ventral process, and from something near *Melyris* the MALACHIINAE may have arisen. The genus *Rhadalus* has been stated to connect MELYRIDAE and CLERIDAE (31), but I have not been able to obtain a specimen for study. Clerid furcae differ from the *Dasytes* type in always having a distinct median projection and primitively in having close anterior tendons. I have not studied sufficient Clerid furcae to be able to discuss the relationships of the subfamilies of CLERIDAE; in *Genera Insectorum* (44) *Tillus* and *Denops* are included in TILLINAE, *Scrobiger*, *Trogodendron* and *Eleale* in CLERINAE, *Pylus*, *Necrobia* and *Corynetes* (and also *Laricobius*) in CORYNETINAE. If these attributions are correct, it does not seem possible to distinguish the subfamilies of CLERIDAE by their furcae. In the TROGOSITIDAE studied, *Tenebroides* and *Leperina* have furcae differing from CLERIDAE chiefly in the separation of the anterior tendons and the small size of the lateral parts of the ventral process, but *Thymalus* differs considerably from them and it will be necessary to study more forms from this family before trying to deduce its ancestral furca. With regard to the DERMESTIDAE, if Böving is correct in including them in the Cleroidea, most of their structure *e.g.* wings (17), aedeagus (46), larvae (3) and the dorsal ocellus of the adult, points to an earlier origin than the other Cleroid families. All the Dermestid furcae I have seen have a somewhat specialised facies (*Dermestes murinus*, *D. peruvianus*, *Attagenus pellio*, *Orphilus niger*, *Trogoderma granaria*, *Anthrenus fuscus*) and certainly cannot represent the ancestral Cleroid type, but may very well have originated from a form in which Hylecoetoid features were only weakly if at all developed. The lateral parts of the ventral process in DERMESTIDAE differ from those of Dascilloidea chiefly in bearing muscle-discs on short stalks, but in *Attagenus* instead of bearing muscle-discs they are drawn out posteriorly into lobes, which differ from the lateral parts of the ventral process in other Cleroidea in not having any connection with the median projection in front.[7] This condition may be primitive, corresponding to an intermediate stage between Dascilloid and Hylecoetoid furcae.

The superfamily Bostrychoidea, with the families ANOBIIDAE, PTINIDAE and BOSTRYCHIDAE (with *Lyctus* and *Psoa*), appears to be most closely linked with the Cleroidea; the more primitive Bostrychoid furcae (*Psoa*, *Lyctus*) have close anterior tendons on a long median projection as in CLERIDAE. In *Ptilinus* the narrow median projection would appear to be a secondary feature as the processes from the posterior sclerotisation to the bases of the anterior tendons arise some distance apart and curve towards each other in front, and in other ANOBIIDAE studied (*Hedobia imperialis*, *Lasioderma serricorne*, *Anobium striatum*, *Sitodrepa panicea*, *Dryophilus pusillus*) as well as in *Ptinus*, *Niptus* and *Gibbium* the median projection is short and the anterior tendons more or less separated. No Bostrychoid furca seen has the lateral parts of the ventral process differentiated as in the typical Hylecoetoid forms, but *Lasioderma* has muscle-discs on stalks as in DERMESTIDAE, while *Psoa* and *Ptilinus* have peculiar little downward projections towards the ends of the furcal arms as in most DERMESTIDAE (cf. 17, 46). Thus it would seem that the ancestral Bostrychoid furca differed from the Dermestid type (and resembled the ancestral Clerid) in having the median projection narrow. The Bostrychoid forms studied (*Psoa*, *Lyctus*, *Dinoderus*, *Hendecatomus*) represent the four subfamilies into which

[7] A careful examination of fresh material, including another species of the genus, has shown that I have misinterpreted this furca, which is essentially like other Dermestids.

Lesne (34) divides the family—according to this author (33) the Malacoderm-like *Chilenius* represents the primitive form of the family, and *Psoa*, which of the forms studied most resembles it, seems to have the most primitive furca.

The forms so far dealt with all agree in having cryptonephridic Malpighian tubules, and in having furcae related to or derivable from the Hylecoetoid type. The ancestral furca of the entire complex would appear to be the ancestral Bostrychid–Dermestid type, and we have now to consider the relationships and origin of this ancestral form itself. The distinctive feature that this ancestral form must have possessed would have been some degree of differentiation of the lateral parts of the ventral process perhaps much as in *Attagenus*, and probably distinct lateral furcal arms. Of forms outside the complex, *Nosodendron* would appear to be nearest to this hypothetical type, and we have to consider whether *Nosodendron* could be descended from a form ancestral to the complex, and if so what are the other relationships of *Nosodendron* itself. From the external structure of the adult, *Nosodendron* has usually been included in Byrrhidae, from the typical members of which it differs in several respects, *e.g.* the abruptly clubbed antennae, large mentum, non-retractable head, less retractile legs, the quite different furca, the wing-venation and folding (17) and in its habits. In Böving's larval system Nosodendridae are placed with Dascillidae, Helodidae and Heteroceridae in the Dascilloidea, which he says are derived from Byrrhoidea by way of Heterocerid forms, but in a recent letter Dr. Böving tells me that the *Nosodendron* larva is "distinctly kindred to Dermestidae." The wing-structure, according to Forbes (*in litt.*), supports this latter conclusion; it is unfortunate that neither the aedeagus nor the Malpighian tubules of *Nosodendron* appear to have been investigated. We may say that there are definite indications of some relation between this genus and Dermestidae, and also with the Dascilloidea and perhaps the Byrrhoidea. It is evident from this that *Nosodendron* represents a distinct family, and an ancient one at that; its geographical distribution also suggests antiquity.

The other forms included in Böving's Dascilloidea that I have seen (*Dascillus*, *Artematopus*, *Helodes*, *Macrohelodes*, *Cyphon*, *Heterocerus*) show no indication of Hylecoetoid features; if we exclude *Heterocerus* they might all be derived from the *Dascillus* furca. All of them have the median projection, if present, short, and the anterior tendons at least slightly separated; a posterior sclerotisation appears always to be present, but true sclerotised furcal arms are not found; the ventral process is well marked and primitively retains its connection with the sternal suture (*Dascillus*). *Eucinetus* has usually been classified (17, 37, 43) near *Cyphon*, but the larva, according to Böving, is entirely unrelated to the Dascilloidea and belongs either at the base of the Cucujoidea (near *Rhizophagus*) or with the Staphylinoid families Leptinidae, Limnebiidae, Liodidae etc. If this is correct, it is very remarkable that there is, as far as I know, not a single character of the adult which would indicate a relation to either of these groups. On the other hand, Dr. Böving, in a letter, tells me that the larvae of Dascilloidea "possess, in fact, the basic characters of the stem Staphylinoidiformia" and so it may eventually prove possible to relate the *Eucinetus* larva to the Dascilloidea. The furca is a very anomalous one, but is obviously very specialised, and may be really related to the *Cyphon* type. *Heterocerus*, by its furca and general adult structure (17, 46), would appear to belong in the Dryopoidea, and in a letter Dr. Böving tells me that its larva is distinctly kindred to the Dryopidae, so I shall discuss it in that group. According to Böving, Dascilloidea are derived from Byrrhoidea, through Heterocerid forms, and in this connection we may note that Dascilloidea (sensu meo) always have the posterior

sclerotisation, while in Dryopoidea (with HETEROCERIDAE) it is weak or absent and in Byrrhoidea (BYRRHIDAE) entirely absent as in *Cupes*.

The Dryopoidea have been the subject of very detailed studies by Hinton (22, 23, 24), and according to this author the forms I have studied should be classified as follows: ELMIDAE (*Potamodytes, Elmis, Xenelmis, Gyrelmis*); LIMNICHIDAE (*Limnichus, Byrrhinus,*[7a] *Lutrochus*); DRYOPIDAE (*Pelonomus, Dryops, Sostea*); PTILODACTYLIDAE (*Ptilodactyla*); PSEPHENIDAE (*Psephenus*). It would be absurd to suppose that my evidence in this group is of equal value to that amassed by Hinton, but it is interesting to note that the evidence of the furca agrees very well with the above arrangement. *Potamodytes* (LARINAE) has on the external structure of the adult usually been classed in DRYOPIDAE, but the furca is close to that of *Elmis* and unlike any Dryopid I have seen. The furcae of the Limnichids are diverse, but not more so than those of some other families, and they certainly resemble Dryopids more than they do any Byrrhid I have seen. The *Psephenus* furca differs rather strikingly from the Dryopids and Elmids I have seen, and the *Ptilodactyla* furca (cf. 17, 46) is more like those of *Heterocerus* and *Pelonomus* than it is to DASCILLIDAE or HELODIDAE. As regards the outside relationships of the Dryopoidea, the lack of any distinguishable posterior sclerotisation in Elmid and Limnichid furcae would suggest a relation to Byrrhoidea while the very strong development of this structure in *Psephenus* might suggest a connection with DASCILLIDAE or even with the Haplogastra. According to Böving, Elateroidea are derived from Dryopoid ancestors near EURYPOGONIDAE; I have not seen any furcae of the latter family but they appear to be close to PTILODACTYLIDAE. Now a larva presumed to be that of *Eulichas* was described by Böving in PTILODACTYLIDAE, and there can hardly be any doubt that the adult of this genus is close to RHIPICERIDAE (*Eulichas* has well-developed empodia, more or less pectinate antennae, furca and wing-structure (17) very close to *Callirhipis*), which are Böving's first Elateroid family. At first sight the furca of *Eulichas* would appear very unlike *Ptilodactyla*, but the only real difference is that the median projection in the former is long and narrow while the latter has it short and truncate. In both the sternal suture is practically absent and the ventral process is drawn forward in the middle.

The Elateroidea of Böving include the following forms I have studied :— RHIPICERIDAE (*Callirhipis*); BUPRESTIDAE (*Ptosima, Sphenoptera, Ethon, Agrilus, Sternocera*); THROSCIDAE (*Throscus, Aulacothroscus*); EUCNEMIDAE (*Nematodes, Melasis*); CEBRIONIDAE (*Cebrio*); ELATERIDAE (*Brachylacon, Cardiophorus, Prosternon, Corymbites, Athous, Agriotes, Denticollis*). If we exclude the BUPRESTIDAE, we may say of this group that the furca always has the stalk, posterior sclerotisation, and ventral process well developed, but the sternal suture is absent. Buprestid furcae are very anomalous, and the presence of a very well-marked sternal suture very like that of *Potamodytes* at once separates them from other Elateroids. It may be mentioned here that Dr. Böving tells me in a letter that Buprestid larvae may belong in the Cleroidea, and according to Poll (40) some Buprestids have cryptonephridic Malpighian tubules (but so also have DRYOPIDAE s.str.—22). The evidence concerning the Buprestids is very conflicting, and they are evidently not closely related to anything else. RHIPICERIDAE would appear to have the most primitive furcae of Elateroidea proper, from the rest of which their larvae differ notably in having a free, distinct labrum (as in Dryopoidea). The EUCNEMIDAE and CEBRIONIDAE are abnormal in the ventral process, while among ELATERIDAE

[7a] Dalla Torre (8) included *Byrrhinus* in the BYRRHINAE, but there is no resemblance to them in its furca.

there is considerable variation in the furca. *Denticollis* in the furca, as in many other respects, approaches the CANTHARIDAE. According to Levtshuk (35) the male of *Denticollis* differs from other ELATERIDAE in that the vasa deferentia open into the ventral instead of the lateral pair of accessory glands; it would be interesting to find out whether this condition obtains in the CANTHARIDAE. There can now be little doubt that the Elateroidea are nearly related to the Cantharoidea; in the latter superfamily, as in the great majority of the former, there are only four Malpighian tubules, no sternal suture in the metasternum, furca with a long stalk and distinct posterior sclerotisation, larva with a nasale, moreover the two groups resemble each other in wing-venation and folding (16, 17) and there are transitional forms connecting them (*Denticollis*, *Brachypsectra*). The old idea that Malacodermata are particularly primitive is scarcely tenable today, and there does not seem to be any direct connection between Cantharoidea and CLERIDAE, MELYRIDAE, or LYMEXYLONIDAE. Of the Cantharoid families the most Elaterid-like in the furca are the CANTHARIDAE and LAMPYRIDAE; *Lycus* and *Drilus* would not appear to be more primitive than these in the furca.

Böving's superfamily Byrrhoidea includes the single family BYRRHIDAE with three subfamilies BYRRHINAE, AMPHICYRTINAE and LIOINAE. The Byrrhoidea are regarded by Böving as being near the ancestral stock from which Dascilloidea, Dryopoidea, Cleroidea and possibly Bostrychoidea and Pseudotetramera were derived (cf. 46). As indicated above, I regard Bostrychoidea as an offshoot of early Cleroidea and the Pseudotetramera as related to Cucujoidea, which themselves arose from Cleroidea. The Cleroidea themselves, if we judge by their furcae, would seem to be related to Dascilloidea by way of *Nosodendron* rather than directly to the Byrrhoidea. Thus we are left with only the two groups Dryopoidea and Dascilloidea which I consider may be directly related to the Byrrhoidea. All the forms I have studied belong to the BYRRHINAE (*Byrrhus*, *Cytilus*, *Simplocaria*, *Syncalypta*, *Microchaetes*), and in all of them the furca has a short stalk, a broad median projection bearing separated anterior tendons, a strong ventral process, no perceptible posterior sclerotisation, and the sternal suture is weaker, hardly distinguishable. If the Byrrhoidea really are of more primitive origin than the forms so far considered, then the absence of a posterior sclerotisation may be a primitive feature (it is absent in *Cupes* and apparently in Adephaga). Among the Dryopoidea the forms which most closely approach Byrrhoidea (ELMIDAE–LARINAE, LIMNICHIDAE) also lack the posterior sclerotisation.

There remains one more family to be considered which may be related to the Byrrhoidea—*i.e.* the DERODONTIDAE. Sharp (49) described them as "one of the smallest and least known families of the Coleoptera," and placed the family between DRYOPIDAE and CIOIDAE; Ganglbauer put them between THORICTIDAE and LATHRIDIIDAE. The wing-structure, according to Forbes (17), is most like COCCINELLIDAE but also is not very dissimilar from *Georyssus*, ANTHRIBIDAE or even *Cytilus*, all of which are included in the group "Dryopiformia." The aedeagus, according to Sharp and Muir (46), is a simple trilobe type, not very unlike those of BYRRHIDAE, DASCILLIDAE, DERMESTIDAE etc. Meixner places DERODONTIDAE near NOSODENDRIDAE and DERMESTIDAE in his Byrrhida (37). In Böving's larval system, as mentioned above, the family is placed at the base of the Cucujoidea and is said to be annectant to the "Limnebiid association" of the Staphylinoidea. According to Böving, the chief feature separating DERODONTIDAE from the remaining Cucujoidea is the distinctly divided maxillary molar. From an examination of Böving's figures, I cannot see anything in the structure of this larva which would preclude it from being related to *Nosoden-*

dron. Adults of the DERODONTIDAE have been stated (43) to have two dorsal ocelli, but Meixner (37) denies this and I have not been able to confirm it in my slide of *Derodontus*. This character is otherwise only known in SILPHIDAE, STAPHYLINIDAE and LIMNEBIIDAE. The furca of *Laricobius* (which was formerly included in CLERIDAE–CORYNETINAE—44) is a very peculiar type. In general appearance it at first suggests NITIDULIDAE, but by the absence of a posterior sclerotisation, the strong ventral process without differentiated lateral parts, the presence of a median projection and of a weak sternal suture, it seems really most nearly related to BYRRHIDAE. It would be of great interest to examine the Malpighian tubules and other features of the internal anatomy of DERODONTIDAE. At all events, it is evident that this family is not closely related to any other existing group of beetles, so I propose for it a separate superfamily **Derodontoidea** superfam. n.

The superfamily Hydrophiloidea of Böving does not quite correspond with the old group Palpicornia, as HISTERIDAE are included while *Ochthebius*, *Hydraena* and *Limnebius* are excluded. In my opinion the older view is the correct one; as d'Orchymont (38) points out, the LIMNEBIIDAE have the characteristic Palpicorn antenna, and the genus *Hydrochus*, which Böving separates from LIMNEBIIDAE and retains in Hydrophiloidea, is unquestionably near to *Hydraena* in adult structure. When adult structure is taken into account, HISTERIDAE can hardly be retained in Hydrophiloidea, and I think there should be a separate superfamily to contain SYNTELIIDAE, NIPONIIDAE and HISTERIDAE (cf. 17, 46.). In my view, then, the Palpicorn forms studied should be classified somewhat as follows :—LIMNEBIIDAE (*Limnebius*, *Ochthebius*, *Hydrochus*, *Hydraena*); SPERCHEIDAE (*Spercheus*); HELOPHORIDAE (*Helophorus*, *Meghelophorus*); HYDROPHILIDAE (*Hydrophilus*, *Hydrobius*, *Helochares*, *Laccobius*, *Sphaeridium*, *Cercyon*, *Megasternum*). Of these we may say that the sternal suture, if present, is very close to the hind margin of the metasternum (in Histeroidea and Lamellicornia it is apparently entirely absent), the furca always has a narrow stalk, strong lateral arms, some development of the median projection, separated anterior tendons, a distinct posterior sclerotisation, and the ventral process more or less as in the Dascilloidea (and SILPHIDAE and Lamellicornia). It does not, of course, follow that all these characters were found in the furca of the ancestral Palpicorn; on a priori grounds it seems more likely that the anterior tendons would have originally been contiguous, as they are in the primitive forms of most other groups of Coleoptera. In this case the ancestral Hydrophiloid furca would have been very near the ancestral Lamellicorn, differing perhaps in the distinct development of the sternal suture. Tillyard (50), from the discovery of a fossil elytron in the lower Triassic which had an alula and resembled the modern *Hydrophilus*, regarded the Palpicorns as one of the most ancient groups of existing beetles. The presence of the alula, of a Y-shaped epicranial suture, of two dorsal ocelli in some LIMNEBIIDAE, the trilobe aedeagus (46), and the movable urogomphi of the larva may all be taken to favour this theory. But on the other hand the Palpicornia possess all the special characters which separate Polyphaga from Adephaga and Archostemata, and hence can hardly be of more ancient origin than Polyphaga as a whole. The presence of a distinct posterior sclerotisation in the furca also argues against the Palpicornia having a more primitive origin than other Polyphaga. Of the groups so far considered, *Psephenus* and the Dascilloidea show the nearest approach to the Hydrophiloid furca.

The Staphylinoidea of Böving's classification correspond very closely with Ganglbauer's group, except for the exclusion of HISTERIDAE and the inclusion of LIMNEBIIDAE. I would exclude both these groups, and feel doubtful about

the inclusion of SCAPHIDIIDAE, which seem to me to have much in common with Histeroidea. The forms I have studied might be classified as follows—SILPHIDAE–NECROPHORINAE (*Necrophorus*); SILPHINAE (*Pteroloma, Necrophilus, Thanatophilus, Phosphuga*); ANISOTOMINAE (*Liodes, Hydnobius, Agathidium*); CHOLEVINAE (*Choleva, Nargus, Ptomaphagus*); LEPTINIDAE (*Leptinus*); CLAMBIDAE (*Calyptomerus, Clambus*); STAPHYLINIDAE (*Acidota, Omalium, Lathrimaeum, Olophrum, Phyllodrepa, Lesteva, Coryphium*; *Metopsia, Megarthrus, Proteinus*; *Deleaster, Coprophilus, Haploderus, Platystethus, Trogophloeus, Oxytelus*; *Siagonium, Piestus*; *Phloeocharis*; *Syntomium*; *Megalopsidia, Euaesthetus, Stenus*; *Osorius*; *Oxyporus*; *Quedius, Ontholestes, Philonthus, Baptolinus*; *Paederus, Stilicus*; *Bolitobius, Mycetoporus, Tachyporus, Tachinus*; *Atheta, Myrmedonia*); PSELAPHIDAE (*Euplectus, Pselaphus, Bibloporus, Bythinus, Tychus*); SCYDMAENIDAE (*Cephennium, Neuraphes*); PTILIIDAE (*Acrotrichis, Ptenidium*); HYDROSCAPHIDAE (*Hydroscapha*). Of all these it can be said that the metasternum never has a sternal suture, the furca always has a posterior sclerotisation and more or less well-marked arms, and Hylecoetoid features are always absent.[8] In most forms there is a well-marked stalk, and in the more primitive types (most SILPHIDAE, *Acidota, Oxyporus, Megalopsidia*) there is a well-marked median projection with close anterior tendons. Many writers (*e.g.* Böving, Meixner, Ganglbauer) have regarded the Staphylinoidea as the most ancient group of Polyphagous beetles; the movable urogomphi of the larva and the abdominal structure of the adult (29) may be taken as favouring this view, but on the other hand the reduction of the Malpighian tubules to four (40), the aedeagus (46), the wing-venation and the furca all show derivative features, in all of which the Staphylinoids might be derived from the Dascilloids but hardly vice versa. At all events, I think there can hardly be any doubt that Staphylinoidea are related to Hydrophiloidea, which latter are in several respects more primitive, *e.g.* in the six Malpighian tubules, the epicranial suture, the sternal suture, the alula, the wing-venation.

Forbes (17) put *Micromalthus* with *Cupes* in the suborder Archostemata, while referring *Lepicerus* (*Cyathocerus*) to the Adephaga; the first conclusion is supported by the larval structure, and the structure of the *Micromalthus* furca is quite consistent with it. I am inclined to suspect that *Lepicerus* will prove to belong in the Archostemata rather than in the Adephaga proper, but until the larva is discovered the position of this genus must remain highly speculative. The *Lepicerus* furca is of the pair of arms type, unknown in the Adephaga but found in various specialised Polyphaga.

The Adephaga, with Lamellicornia, constitute the two best characterised groups in the Order. If *Rhysodes* is excluded, Adephaga are easily recognised in the furca thus: a narrow stalk always present, anterior tendons separated by a median excavation, no posterior sclerotisation, no true furcal arms, hind coxae with inner end produced anteriorly. The essential differences between this and the condition in *Cupes* are the median excavation separating the anterior tendons, and the coxal process. *Rhysodes* has close anterior tendons on a long median projection, as in *Cupes*, but the coxal process is present and in other respects (wing-structure, aedeagus, presence of a bristle in the mandibular scrobe, the excavation of the inner side of the front tibia, the divided first abdominal sternum, the structure of the mesopleuron) RHYSODIDAE (cf. 19) would seem closest to CARABIDAE. Various features of CICINDELIDAE, *e.g.* the presence of a basal piece in the aedeagus (46), the plurisetose labrum, the wing-folding (17), the small and

[8] Blackwelder (4) figures peculiar muscle-discs on the furcal arms in *Creophilus*; I have not seen anything like them in my preparations of *Ontholestes* and *Philonthus*.

narrow excavation between the anterior tendons, would indicate an origin from something more primitive than any existing CARABIDAE. Only a single Cicindelid furca has been examined but I hope eventually to study several more. The enormous family CARABIDAE is by far the most difficult of all to classify on the basis of the furca. The one thing that I can say of them with reasonable certainty is that the furca which comes nearest to *Cicindela* is that of *Calosoma*, and that all Carabid furcae I have seen could be derived from this type. A considerable number of furcae have been studied (*Calosoma*, *Ceroglossus*, *Carabus*, *Pseudozaena*, *Elaphrus*, *Notiophilus*, *Nebria*, *Leistus*, *Omophron*, *Loricera*, *Clivina*, *Hexagonia*, *Bembidion*, *Asaphidion*, *Patrobus*, *Tefflus*, *Panagaeus*, *Badister*, *Calathus*, *Pterostichus*, *Amara*, *Harpalus*, *Adelotopus* (PSEUDOMORPHINAE), *Lebia*, *Demetrias*, *Dromius*, *Brachinus*, *Triaenogenius*, *Anthia*, *Pheropsophus*). The major division adopted by most authors (CARABINAE–HARPALINAE) is hardly to be recognised in the furca, and the same is true of the division of HARPALINAE into Intruncatipennes and Truncatipennes, and of the Intruncatipennes into Impilae and Piliferae (1, 9). The most conspicuous division in the furcae is into big Carabids and small Carabids! The large forms (*Carabus*, *Ceroglossus*, *Calosoma*, *Tefflus*, *Anthia*) have the stalk and " arms " (not homologous with the arms of Polyphaga) more or less broad and flat, so that the furca could be represented by a shape cut out of cardboard, while in small forms the stalk and arms are narrow and more or less tubular. This may indicate that in the family as a whole, large size is a primitive character. Points of detail that emerge are that of the Carabini, *Ceroglossus* [9] is very close to *Carabus* while *Calosoma* approaches *Elaphrus* and NEBRIINAE, that the *Pseudozaena* furca is very specialised but I suspect that it comes from a very primitive ancestral type (cf. *Gyrinus*), that there is nothing particularly primitive in the *Hexagonia* furca (1), that the *Patrobus* furca is similar to *Pterostichus* rather than to *Bembidion*, that *Dromius* and *Demetrias* are not at all close to *Lebia*, that the *Anthia* furca is more like *Triaenogenius* (Helluonini) than to any other I have seen, and that there is nothing unusual in the *Adelotopus* (PSEUDOMORPHINAE) furca. There is now little reason to doubt that PAUSSIDAE are most nearly related to CARABIDAE–Ozaenini (10); it would be interesting to see whether the aedeagus in Ozaenini has a basal piece, as in PAUSSIDAE but not in Carabids as far as known (46). It is now generally believed that the Hydradephaga are derived from CARABIDAE or something close to that family; the furcae of *Amphizoa* and *Hygrobia* are quite consistent with this, and differ little from those of some CARABINAE *e.g.* Nebriini. But these Hydradephaga, like PAUSSIDAE and CICINDELIDAE, have a basal piece in the aedeagus and in that respect are more primitive than Carabids (as far as known). The GYRINIDAE are anomalous in the aedeagus, which according to Sharp and Muir (46) is a trilobe type and thus apparently more primitive than those of other Caraboids; the larva, wing-structure (17) and furca of *Gyrinus* do not appear to have any primitive features not found in other Caraboidea.

V. General Conclusions.

In my previous paper, the two chief conclusions reached were that all Coleopterous furcae are derived directly or indirectly from a type similar to that of *Cupes*, and secondly that the Hylecoetoid furca is of monophyletic origin. The first conclusion, was, I think, established with reasonable certainty, and I still know of no important evidence against it, but the second raises many difficulties and though I believe it to be true it cannot be said that the phylogeny

[9] According to Lapouge (30) *Ceroglossus* is the most primitive of Carabini.

which this implies is at present accepted by any considerable number of coleopterists. To establish this theory it is first necessary to be able to distinguish furcae derivable from the Hylecoetoid type from those which are not. This I claim to be able to do in the great majority of cases by the application of the following principles :—

1. The presence of a narrow stalk is more primitive than its absence.
2. Contiguous anterior tendons are more primitive than separated ones and, with a few probable exceptions, narrowly separated ones are more primitive than widely separated ones.
3. The presence of a median projection bearing the anterior tendons is a primitive feature (CHRYSOMELIDAE–Camptosomata and one or two Curculionids are probable exceptions).
4. The complete absence of a posterior sclerotisation is a primitive feature.
5. The presence of a sternal suture, well in front of the hind margin of the metasternum, is a primitive feature and this suture primitively connects with the ventral process of the furca.
6. The presence of sclerotised furcal arms is a derivative feature.
7. With a few possible exceptions, furcal arms pointing laterally are more primitive than arms pointing antero-laterally.
8. In furcae derived from the Hylecoetoid type, the presence of well-differentiated lateral parts of the ventral process is a primitive feature.

The original Hylecoetoid furca is assumed to have been primitive in principles 1, 2, 3 and 7, derivative in 4 and 6 and more or less so in 5; the typical Hylecoetoid feature in 8 is derivative in relation to non-Hylecoetoid types. The chief difficulty that arises in practice is to distinguish Hylecoetoid furcae which have lost the typical feature in 8 from Staphylinoid types, as Staphylinoidea are also always specialised in 4, 5 and 6. This is usually easily done when the other characters (wings, aedeagus, larva, etc.) are taken into consideration, and in nearly all such cases it is possible to find a form from the same or a closely related family which shows the typical features in 8. The most serious difficulty arises in the superfamily Bostrychoidea, of which none that I have seen shows the Hylecoetoid feature in 8; they are all, however, specialised in 4, 5 and 6, and there is not the slightest evidence that they are connected with the Staphylinoidea, and several Bostrychoid furcae have at least two features in common with DERMESTIDAE and no other form known to me. Dermestid furcae themselves have a superficial resemblance to HELOPHORIDAE, but at least *Attagenus* has some differentiation of the lateral parts of the ventral process.

By the application of these principles it can be shown that all the forms I have seen from Böving's superfamilies Curculionoidea, Platystomoidea, Chrysomeloidea, Cerambycoidea, Bostrychoidea, Meloidea, Mordelloidea, Cucujoidea (excluding *Eucinetus* and DERODONTIDAE), and Cleroidea have furcae derivable from or related to the Hylecoetoid type, while in the superfamilies Byrrhoidea, Dascilloidea, Dryopoidea, Elateroidea and Cantharoidea none of the forms studied are derivable from the Hylecoetoid type. This was stated in my previous paper, but in the material on which that paper was based the Byrrhoidea, Dascilloidea, Dryopoidea, Elateroidea and Cantharoidea were represented by 3, 3, 1, 5 and 3 species respectively, hence it was possibly rather premature of me to state that Hylecoetoid furcae were entirely absent in those groups ! One of the objects of the present paper was to study as representative a series of forms as could be obtained from these groups—furcae of 3 more Byrrhoidea, 4 more Dascilloidea (1 fresh family and 1 fresh subfamily), 11 more Dryopoidea (4 fresh families), 7 more Elateroidea (1 fresh family), and 2 more

Cantharoidea (each of a fresh family) are dealt with in it. As a result I can state that the Dryopoidea in particular show a considerable range of furcal types but that my original statement as to the absence of Hylecoetoid types holds good. The same is true of additional Hydrophiloid, Staphylinoid and Adephagan types studied. Hence so far the findings of the present investigation are entirely consistent with the theory of my previous paper.

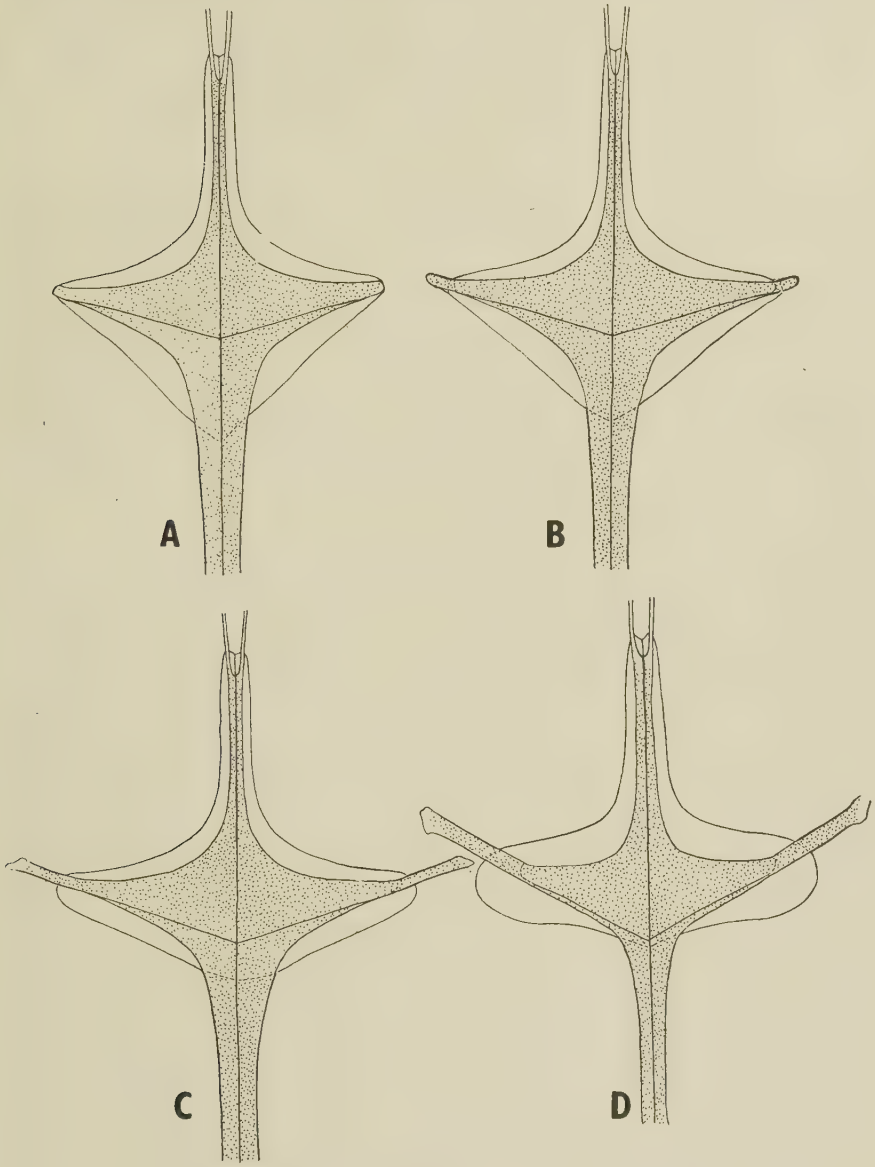
A monophyletic origin of the Hylecoetoid furca would seem improbable on *a priori* grounds, as it is not easy to point to any other structural modification in the Order the origin of which appears to be single. The chief instances known to me where this seems probable are the divided first abdominal sternum of Adephaga (but cf. *Orobitis*) and the peculiar antennae of Palpicornia.

One of the chief reasons for suggesting a single origin for the Hylecoetoid furca is the extraordinary closeness with which it corresponds to cryptonephridism. With the exception of Dryopidae s.str. and of some Buprestidae, all known cryptonephridic beetles seem to have furcae related to the Hylecoetoid type, and practically all beetles with Hylecoetoid furcae (except Donaciinae and Melyridae–Malachiinae) are cryptonephridic. As there is no conceivable causal connection between the two characters, either the possession of them defines a natural group, or we must postulate an almost unparalleled coincidence. There are, in fact, other lines of evidence [10] which tend to indicate a connection between the groups Bostrychoidea, Cleroidea, Cucujoidea and Phytophaga. On external taxonomic characters of the adult Trogositidae, whose relationship to Cleridae can now hardly be doubted, would be classed in Cucujoidea, the Cioidae (which Böving includes in Cleroidea) are sometimes put with the Bostrychoidea and sometimes in Clavicornia, and the primitive Longicorn *Parandra* was actually included in Cucujidae by Tillyard (50). On larval structure, Böving had difficulty in deciding whether certain families (Scalidiidae, Bothrideridae, Mordellidae) were to be referred to Cucujoid or Cleroid ancestors, Bostrychoidea were by this author associated with the Phytophaga and a Cleroid origin for the latter group was considered possible (in a letter Dr. Böving tells me that there is much resemblance between Cerambycid and Melandryid larvae). On wing-venation and folding Forbes associated Cucujidae with Cleridae and classed the Phytophaga near to them. Sharp and Muir also associated Cleridae and Trogositidae with Cucujoid families, and drew attention to the Cucujoid aedeagus in such forms as *Parandra*, *Orsodacne*, *Belus*, Anthribidae etc.

The problem then arises—if the Hylecoetoid furca is of monophyletic origin and characterises the major part of Polyphagan beetles, is it possible to make it the basis of the major division of the Polyphaga? In my view, in a really natural classification, groups should not be set off merely by characters in which they are more specialised than their allies. If the Rhynchophora, for example, are to be given a separate superfamily from the Cerambycidae and Chrysomelidae, in my view this should not be merely because of the rostrum of the adult or the reduced legs of the larva, but chiefly because some of them have a mandibular molar in the larva and a furca with contiguous anterior tendons in the adult. As I do not know of any primitive feature which the ancestral Hylecoetoid beetle can be deduced to have possessed which is not found in other Polyphaga, I do not think the Hylecoetoid group are a primary section of the suborder. The primary division of the Polyphaga seems to me to be into Haplogastra and Symphyogastra (of Kolbe—29—and Forbes), the Haplogastra (= Staphylinoidea, Hydrophiloidea and possibly Scarabaeoidea of

[10] See also a paper by Mansour (36) in which he draws attention to the similar mode of formation of the adult mid-gut in Phytophaga and Cucujoidea.

Böving) being fundamentally more primitive in having two dorsal ocelli, a Y-shaped epicranial suture, the haplogastran abdomen, and mobile urogomphi in the larva, while the Symphyogastra are basically more primitive in the wing-



Figs. A–D.—Stages in the hypothetical development of the Hylecoetid furca D (Cleridae) from the Dascillid type A via B and C.

venation, metasternum and furca, and the lobes of the larval maxilla. The value of the Hylecoetoid furca is that it provides a basis for a further subdivision of the Symphyogastra into two groups, for which I propose the names Dascilliformia and Cucujiformia. The Dascilliformia would comprise Böving's superfamilies Dascilloidea, Byrrhoidea, Dryopoidea, Elateroidea and Can-

tharoidea; they are, in my opinion, basically more primitive than the Cucujiformia in the furca, the simple Malpighian tubules, and the maxilla of the larva. The Cucujiformia may be more primitive in the larval mandible, the urogomphi, and perhaps in the dorsal ocellus of the adult (Dermestidae). The Derodontidae are very difficult to fit into either grouping, the adult being on the whole Dascilliform while the larva is Cucujiform; the family is evidently an ancient one and may represent a third group related to the Dascilliformia and Cucujiformia as the Cupedidae are to the Adephaga and Polyphaga.

VI. Note on the Origin of the Hylecoetoid Furca.

It is probable that the Hylecoetoid furca was evolved from a Dascillid-like type. I have tried to indicate a possible way in which this could happen in the accompanying text-figures (A–D); A represents a Dascillid type, D a primitive Clerid form, while B and C are hypothetical intermediate forms. In A there are no distinct furcal arms, in B they are just beginning to develop and the lateral ends of the ventral process have just established continuity with the more membranous part of the median projection, in C both these developments have gone further, while in D the lateral parts of the ventral process are becoming differentiated from the narrow central part. It seems likely that most of the individual stages in the development of the Hylecoetoid furca occurred polyphyletically but that only on one line of descent was the whole process gone through.

VII. Corrections to Previous Paper.

There were several serious errors, both of fact and of interpretation, in my former paper on this subject (7). The furca of *Hylecoetes* was described (p. 399) as one of the most primitive in the Order; this should read " is close to the primitive type of a large section of the Polyphaga ". In describing the furca of this form, the stalk was said to broaden out into the lamina (= lateral part of the ventral process), whereas it is the furcal arms and not the lamina that arise from the apex of the stalk. Throughout the descriptive part of the paper the descriptions, as I now realise, were insufficient and often misleading; in the present I have tried to give clear, systematic descriptions of the forms dealt with. Several of the figures and descriptions of the previous paper were wrongly attributed—the *Hyliota* furca was described and figured as *Hemipeplus* and vice versa (p. 401, pl. 3 figs. 5–6); the figure of the *Colasposoma* furca represents *Timarcha tenebricosa*, so I include a figure of the *Colasposoma* furca in the present paper (fig. 86); the *Thanatophilus* furca was figured and described as *Phosphuga* and vice versa (pl. 9 figs. 7–8); the figures of *Micropeplus* and *Dascillus* (pl. 8 fig. 1, pl. 10 fig. 11), drawn from damaged specimens, were quite incorrect (both are dealt with in the present paper); there are more or less serious errors in the figures of *Thymalus* (pl. 4 fig. 2), *Agriotes* (pl. 7 fig. 6), *Clytra* (pl. 5 fig. 9), and *Diphyllus* (pl. 3 fig. 11); the figure of *Anobium* (pl. 8 fig. 8) represents a ventral, not a dorsal, view, and the figures of *Onthophagus*, *Thanatophilus* (pl. 9 figs. 1, 8) and *Megalopsidia* (pl. 10 fig. 1) are upside down. *Oides collaris* referred to in my previous paper is now figured (pl. 10 fig. 80).

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Explanation of Plates 1–10.

Plate 1.

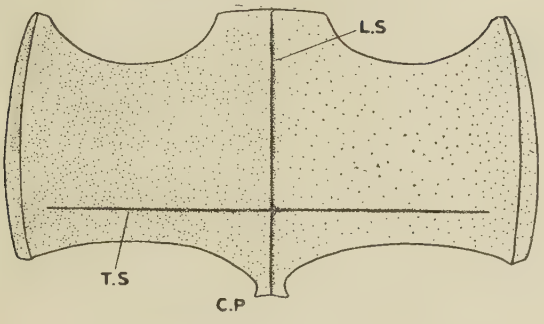
Fig. 1. Metasternum of primitive beetle, ventral view.
2. Metendosternite of Cupedoid type, dorsal view. *a*, *b*—vertical sections of it through lines *AA*, *BB*.
3. Metasternum and furca of primitive beetle, cut vertically along the middle line.
4. Metendosternite of Hylecoetoid type.

Figs. 5–8 : Dorsal views of furcae.

Fig. 5. *Micromalthus debilis.*
6. *Calosoma schayeri.*
Fig. 7. *Nebria brevicollis.*
8. *Pseudozaena orientalis.*

Lettering of the Figures.

L.S.—Longitudinal suture of metasternum.
S.S., T.S.—Transverse suture of the metasternum.
V.P.—Ventral process.
L.—Differentiated lateral part of ventral process.
P.—Posterior sclerotisation.
M.—Membranous part of furca.
A.—Furcal arms.
T.—Anterior tendons (bearing a muscle attaching to the mesendosternite and forming part of the ventral longitudinal series).
F.—Ventral longitudinal flange.
C.P.—Coxal process (in Adephaga).
D.—Dorso-lateral projection } in Adephaga.
L.—Ventro-lateral projection }
W.—Internal flange of longitudinal suture of the metasternum.
Z.—Internal flange of transverse suture of the metasternum.



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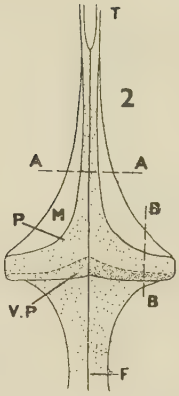

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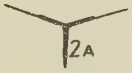

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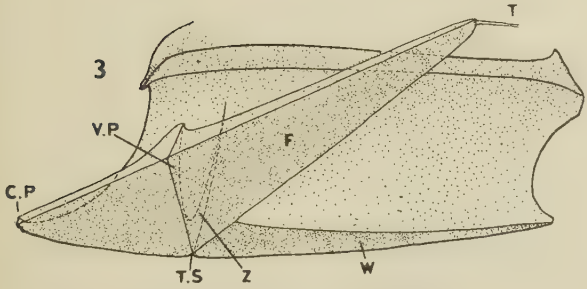

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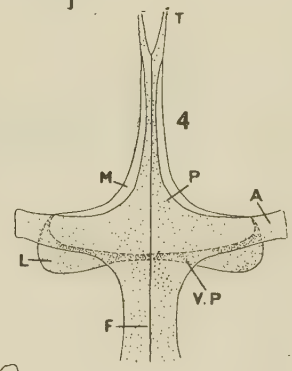

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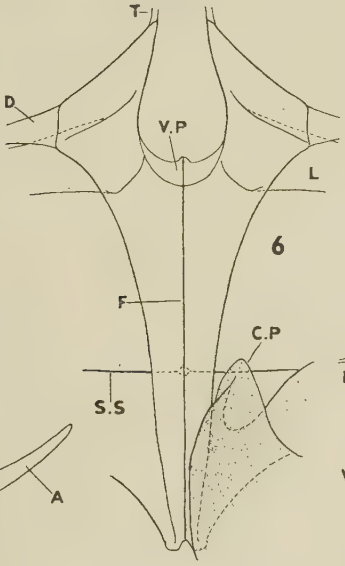

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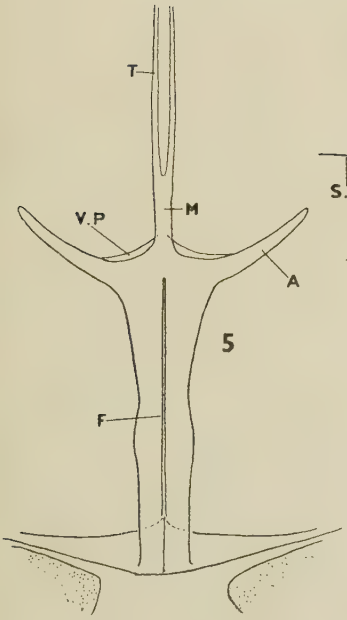

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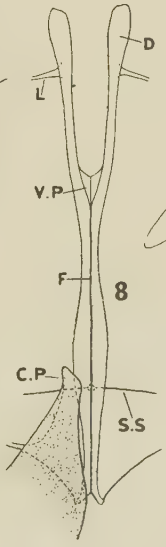

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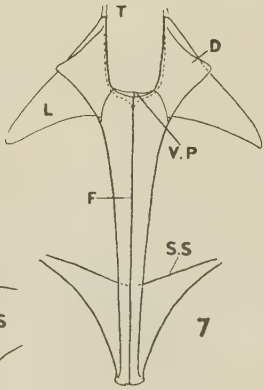

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Plate 2.

Dorsal views of furcae.

Fig. 9. *Tefflus hacquardi.*
10. *Panagaeus 4-pustulatus.*
11. *Lebia chlorocephala.*
12. *Dromius 4-maculatus.*
Fig. 13. *Brachinus crepitans.*
14. *Triaenogenius carinulatus.*
15. *Anthia alternata.*

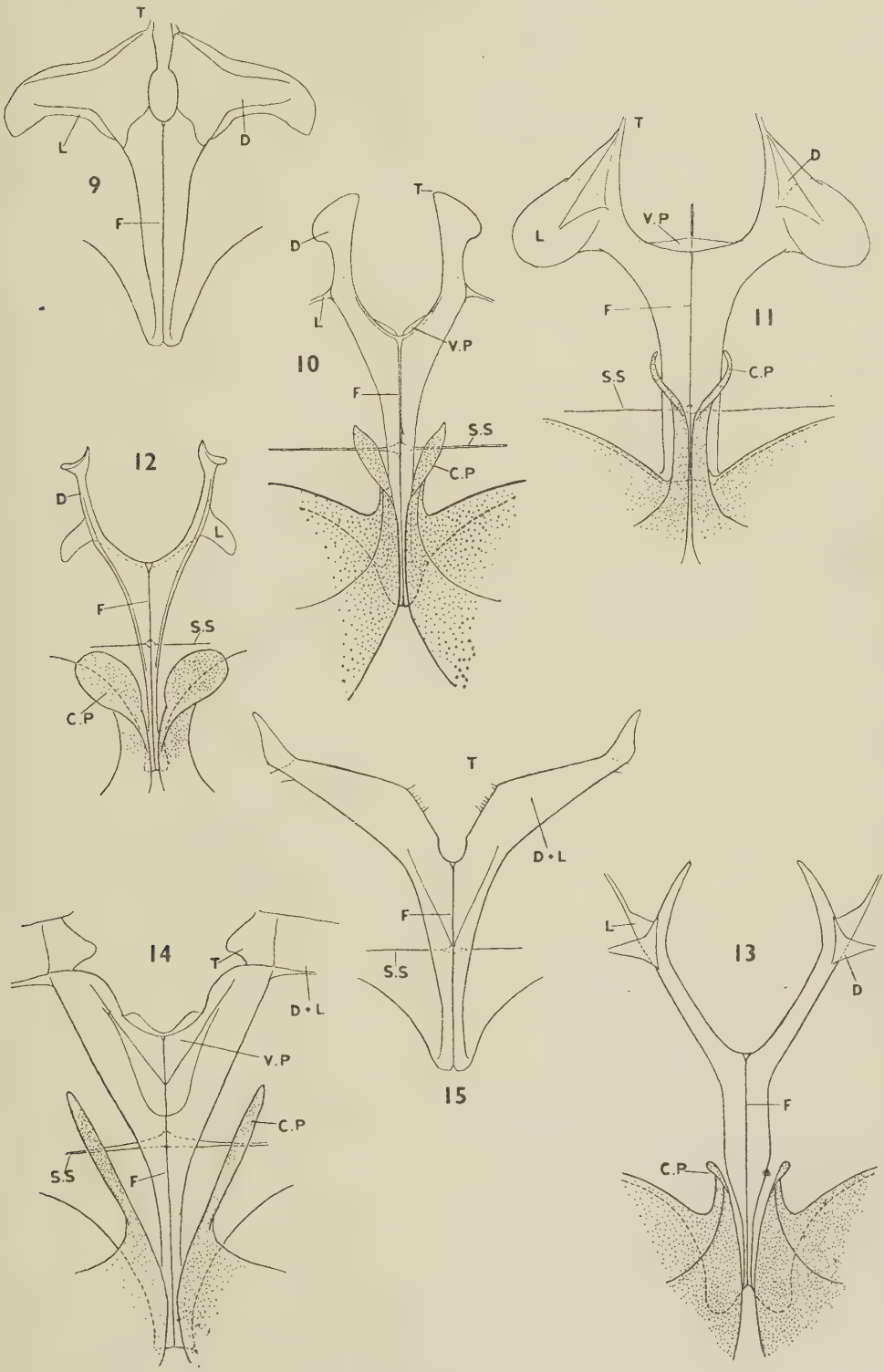
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Plate 3.

Dorsal views of furcae.

Fig. 16. *Pteroloma forsstromi.*
17. *Necrophilus hydrophiloides.*
18. *Metopsia clypeata.*
19. *Oxyporus rufus.*
20. *Osorius puncticeps.*

Fig. 21. *Syntomium aeneum.*
22. *Euplectus* sp.
23. *Bythinus curtisii.*
24. *Pselaphus heisei.*

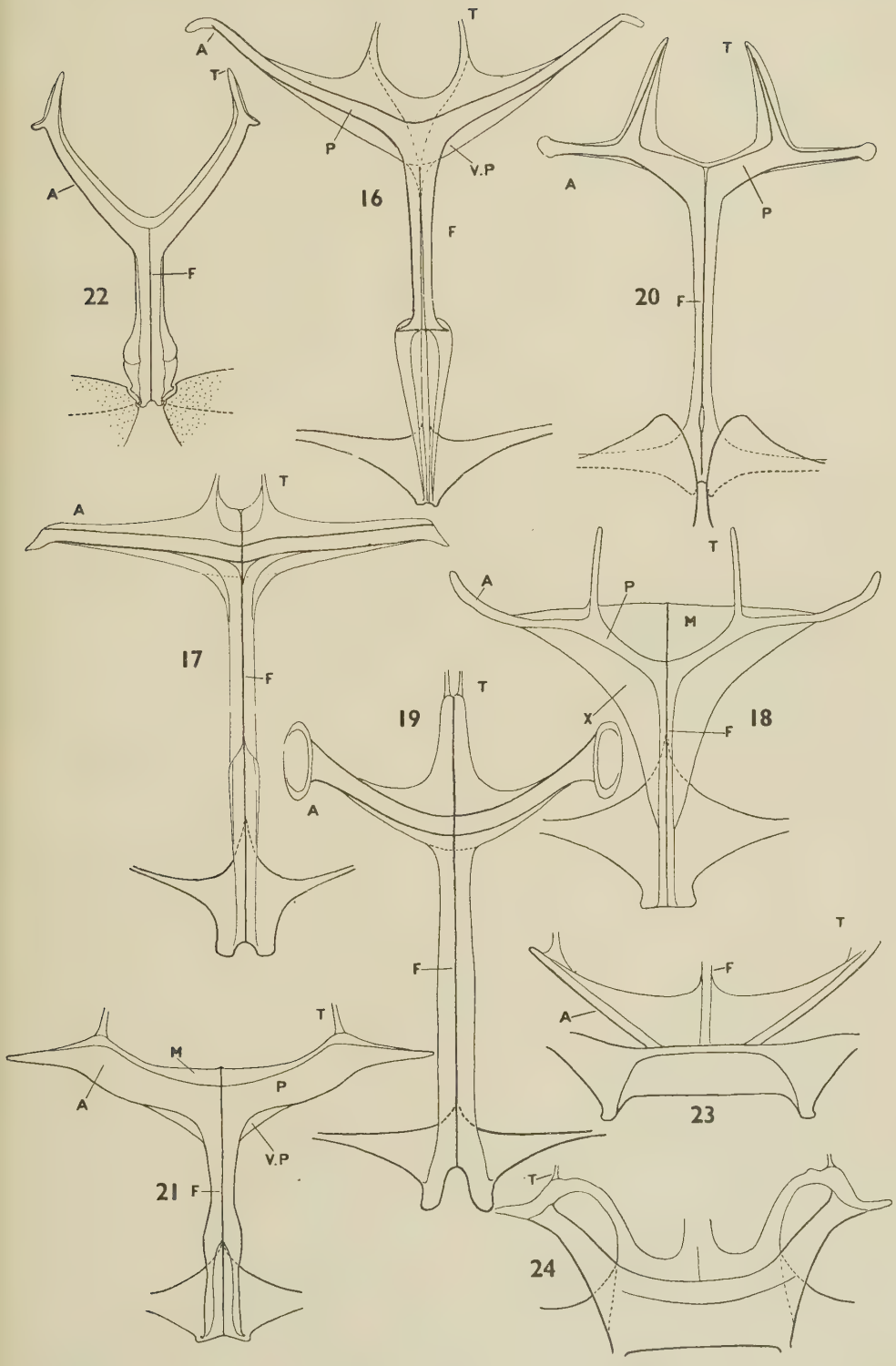
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Plate 4.

Dorsal views of furcae.

Fig. 25. *Ochthebius impressus.*
26. *Spercheus emarginatus.*
27. *Micropeplus porcatus.*
28. *Dascillus cervinus.*
29. *Artematopus rotundicollis.*

Fig. 30. *Eulichas sikhimensis.*
31. *Callirhipis* sp.
32. *Helodes marginata.*
33. *Eucinetus infumatus.*

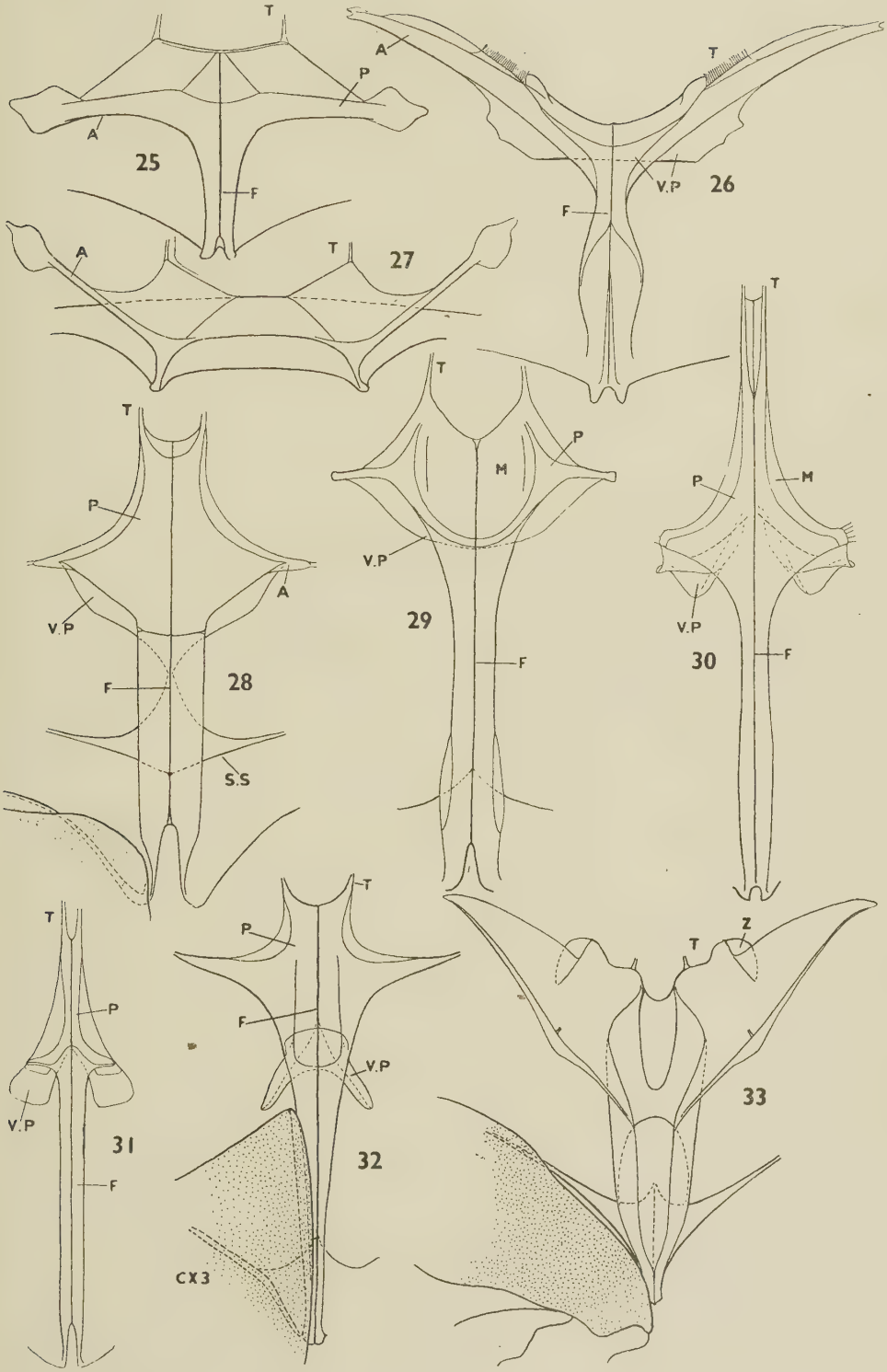
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Plate 5.

Dorsal views of furcae.

Fig. 34. *Ptilodactyla* sp.
35. *Psephenus usingeri.*
36. *Pelonomus* sp.
37. *Potamodytes ochus.*
38. *Elmis maugeti.*
39. *Gyrelmis thoracica.*
40. *Byrrhinus* sp.
41. *Lutrochus gigas.*
42. *Limnichus pygmaeus.*
43. *Sostea* sp.

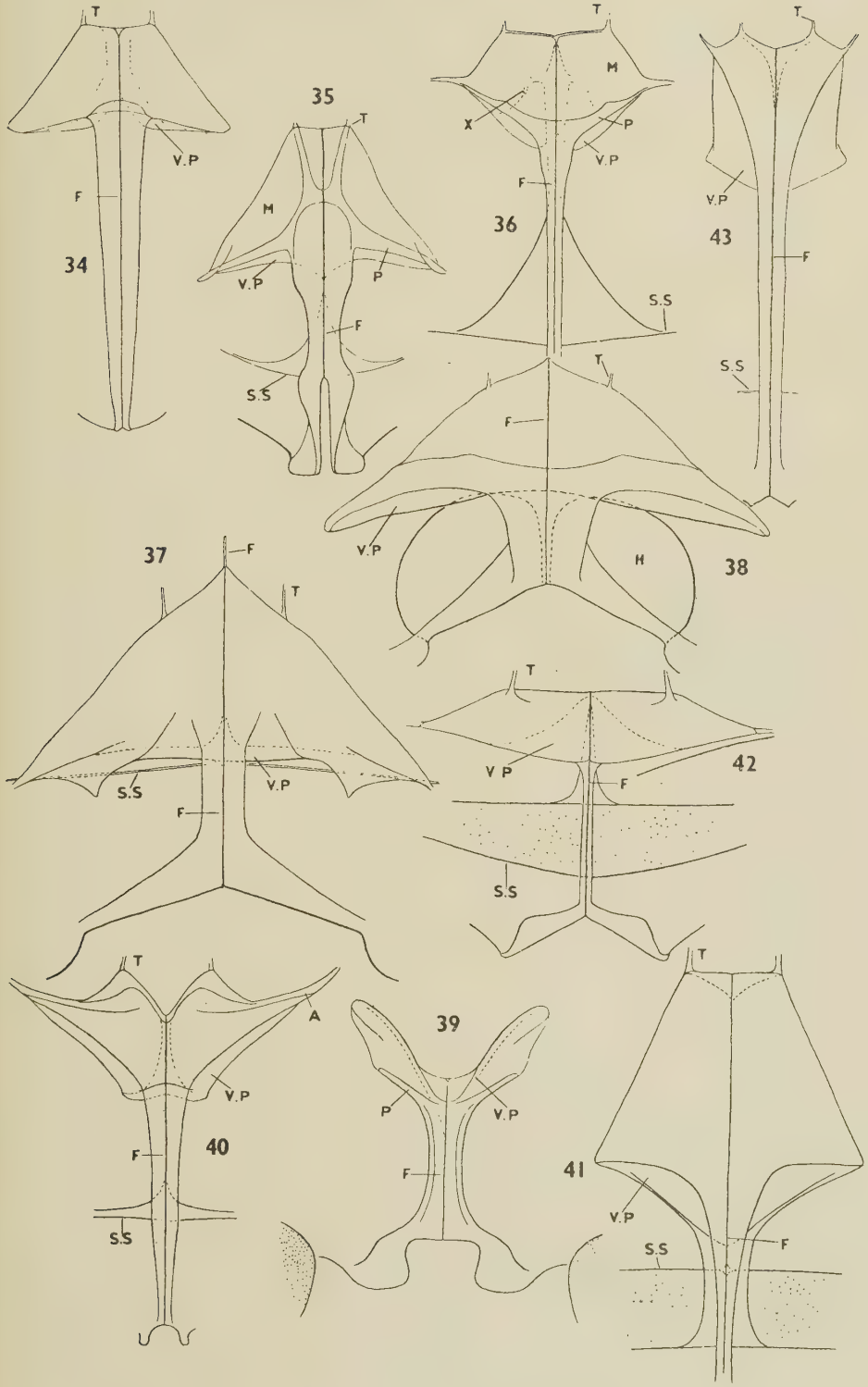
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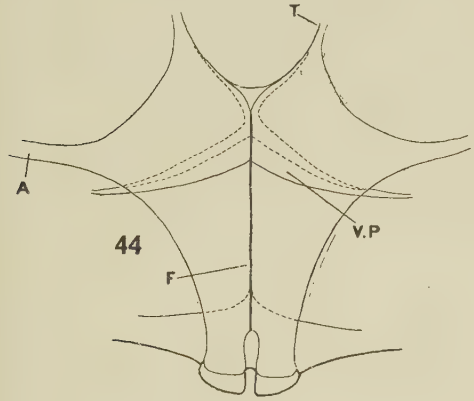
Plate 6.

Dorsal views of furcae.

Fig. 44. *Cytilus sericeus.*
45. *Laricobius erichsoni.*
46. *Derodontus macularis.*
47. *Ptosima flavoguttata.*
48. *Nematodes* sp.
Fig. 49. *Denticollis linearis* (apical part of furca only).
50. *Prosternon holosericeus.*
51. *Drilus flavescens.*
52. *Lampyris noctiluca.*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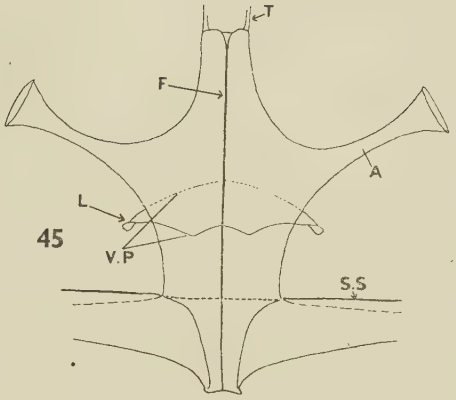
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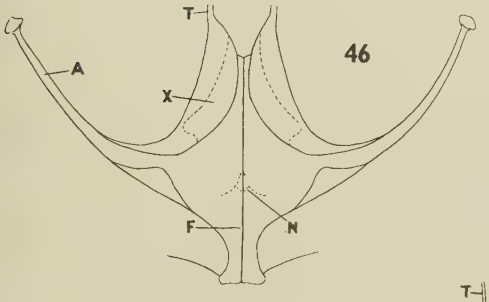
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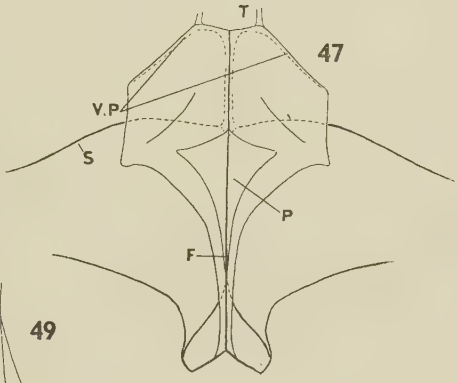
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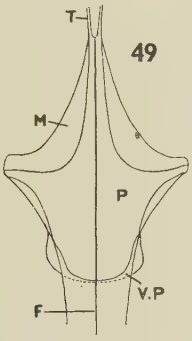
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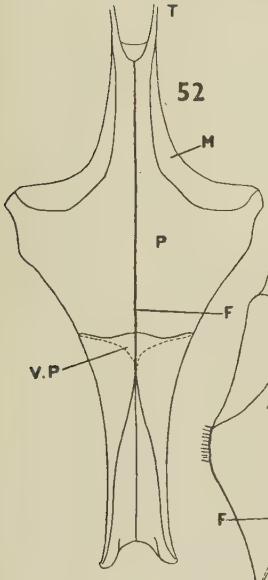
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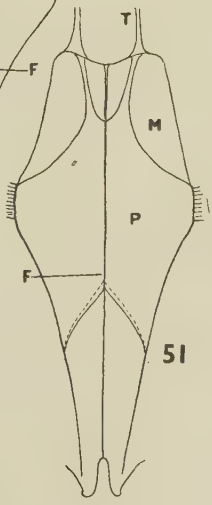
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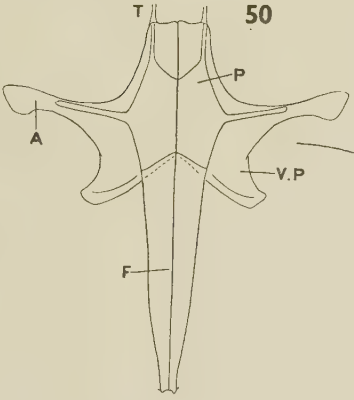
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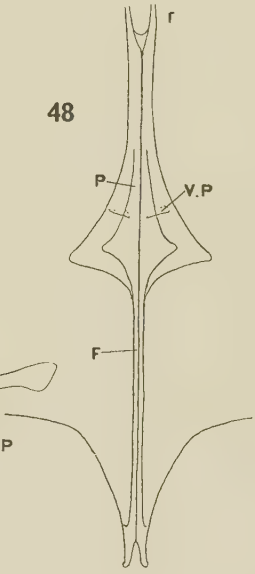
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Plate 7.

Dorsal views of furcae.

Fig. 53. *Nosodendron hispidum.*
54. *Orphilus niger.*
55. *Lasioderma serricorne.*
56. *Ptilinus pectinicornis.*
Fig. 57. *Psoa viennense.*
58. *Tillus elongatus.*
59. *Hendecatomus reticulatus.*
60. *Xylographus bostrychoides.*

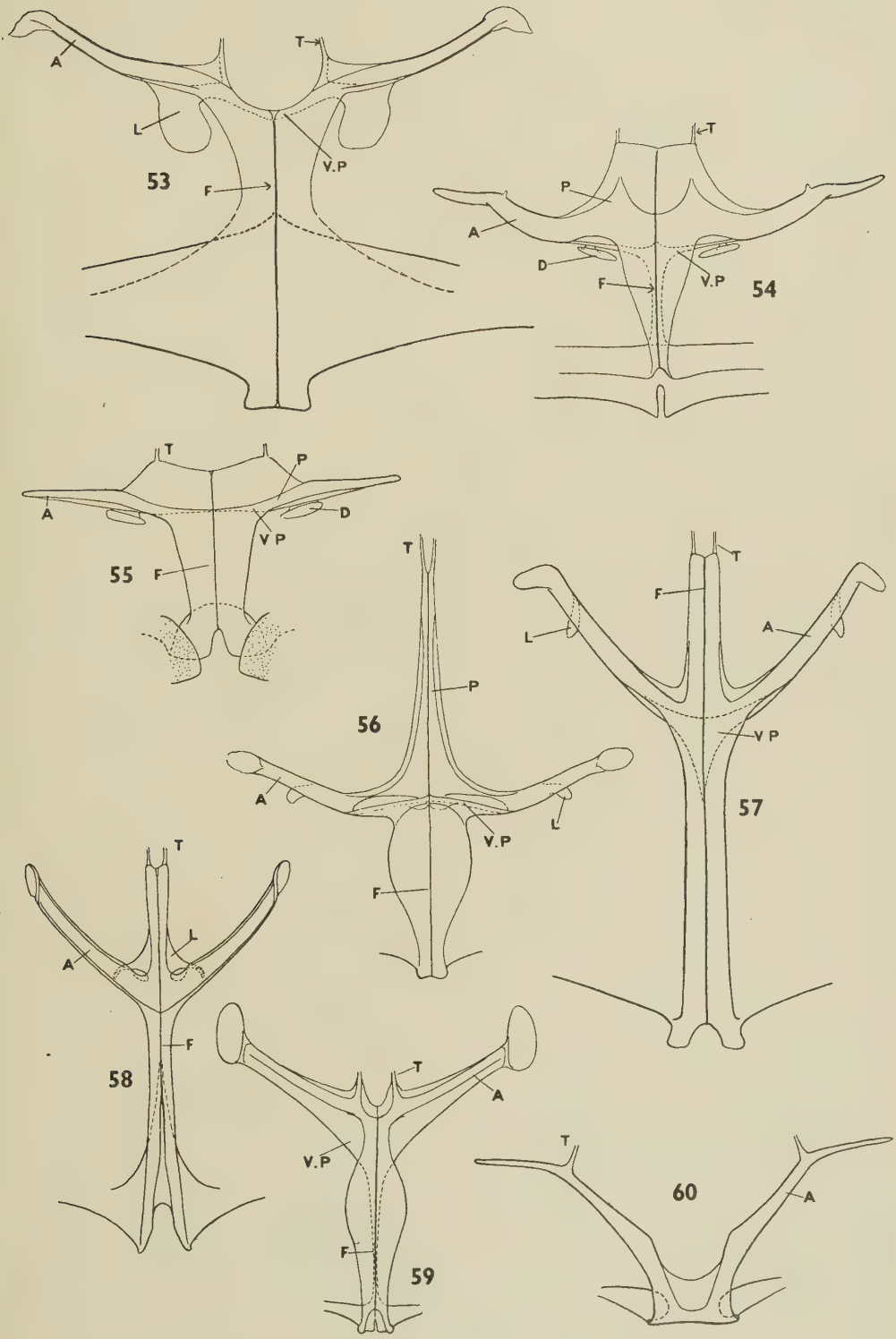
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Plate 8.

Dorsal views of furcae.

Fig. 61. *Corynetes coeruleus.*
62. *Danacaea pallipes.*
63. *Phloeophilus edwardsi.*
64. *Nitidula bipunctata.*
Fig. 65. *Brachypterus urticae.*
66. *Holoparamecus caularum.*
67. *Sphindus dubius.*
68. *Thorictus grandicollis.*

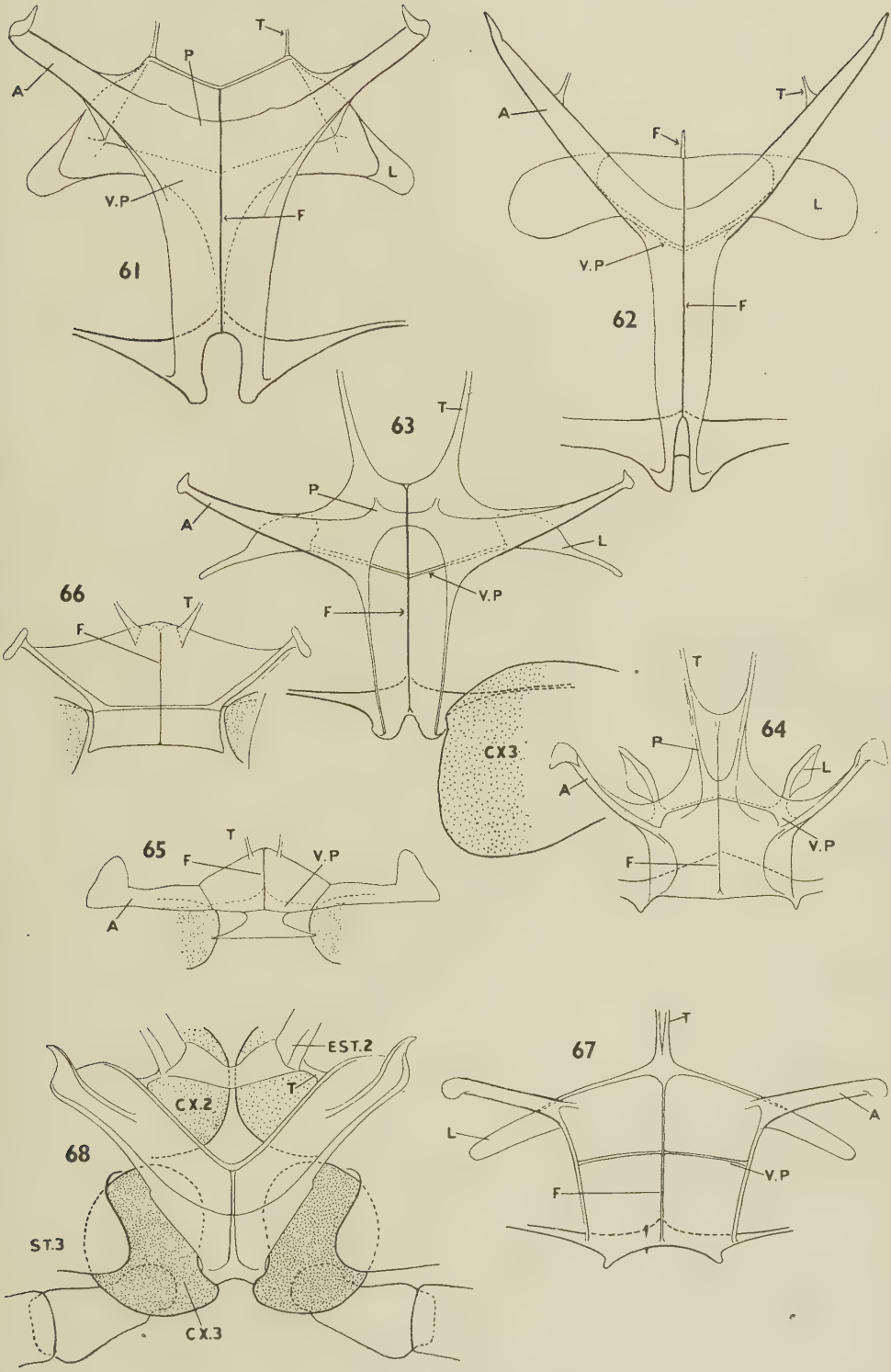
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Plate 9.

Dorsal views of furcae.

Fig. 69. *Byturus tomentosus.*
70. *Orthoperus* sp.
71. *Othnius kraatzi.*
72. *Myrmecoxenus vaporariorum.*
73. *Murmidius ovalis.*
74. *Enarsus bakewelli.*
75. *Georyssus pygmaeus.*
76. *Pterogenius nietneri.*
77. *Hypophloeus bicolor.*

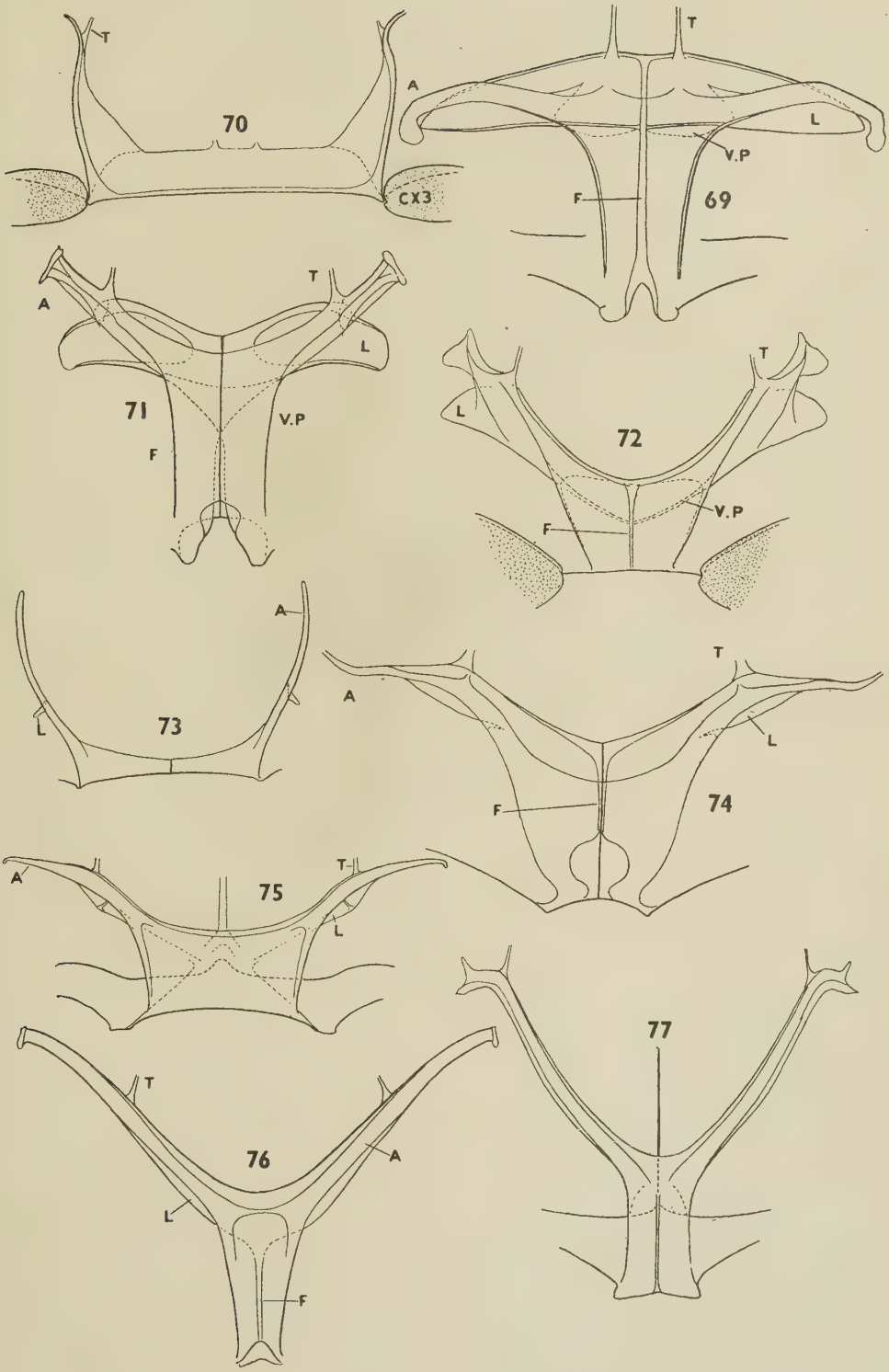
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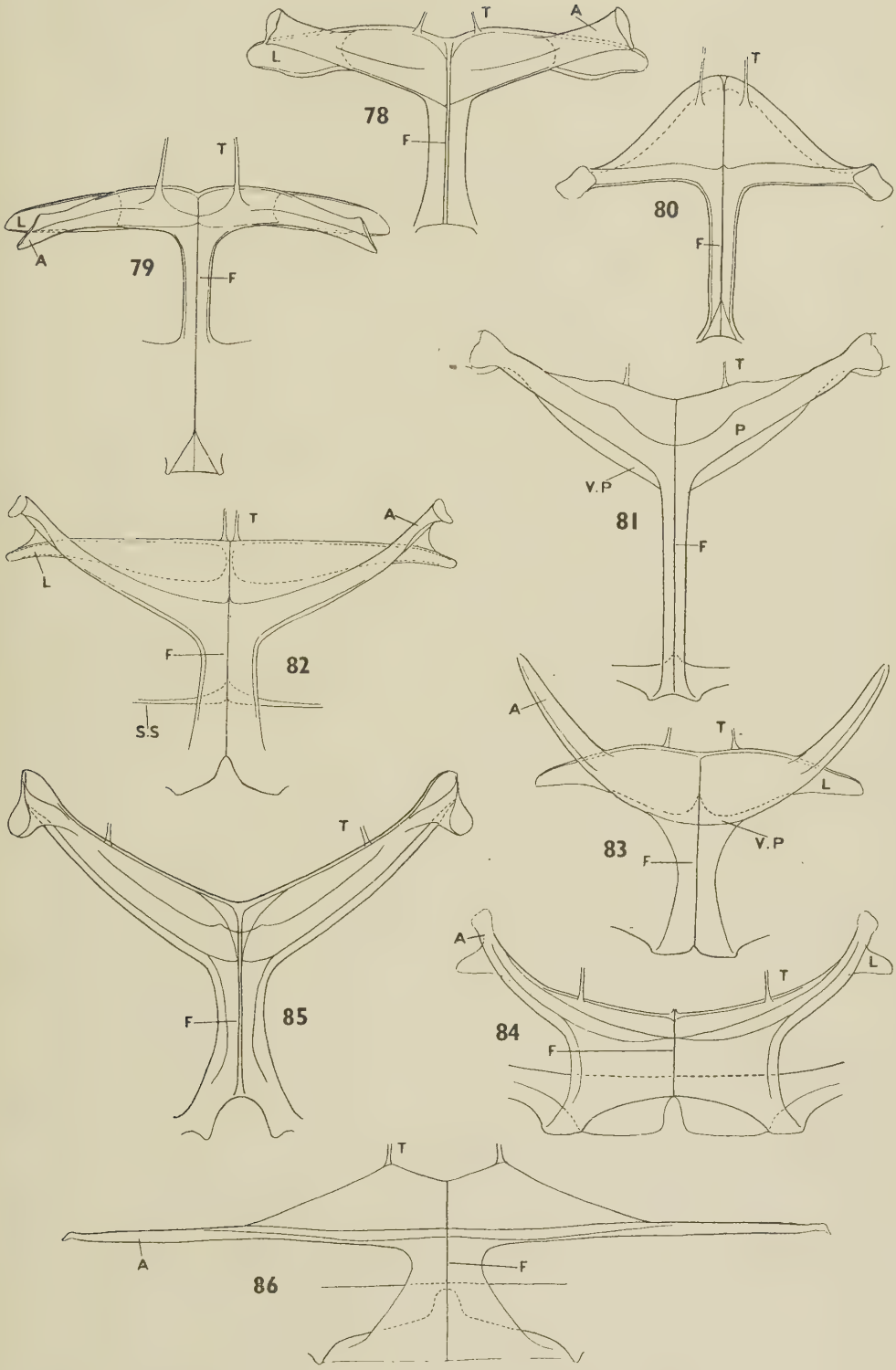
Plate 10.

Dorsal views of furcae.

Fig. 78. *Carpophagus banksiae.*
79. *Mastostethus* sp.
80. *Megascelis viridis.*
81. *Oides collaris.*
82. *Platyrrhinus resinosus.*
Fig. 83. *Mecinus pyraster.*
84. *Baris lepidii.*
85. *Caryoborus rubidus.*
86. *Colasposoma metallicum.*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ON *LIMENITIS BREDOWII* GEYER (LEP., NYMPHALIDAE) WITH DESCRIPTION OF A NEW SUBSPECIES AND REVIVAL OF ANOTHER. A STUDY IN GEOGRAPHICAL DISTRIBUTION AND SPECIATION

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With 4 Plates, 2 Text Figures, 4 Tables and 2 Charts.

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Introduction.

This study was initiated by the senior author, who alone is responsible for all sections except VII to X, and for the photographs, drawings, charts, and tables 1 and 2. Dr. B. M. Hobby, assistant to the professor, kindly helped with the laborious statistical analysis by means of a calculating machine recently presented to the Hope Department of Entomology by the Trustees of the Christopher Welch fund. The sections dealing with the results of this analysis and Tables 3 and 4 are the joint work of both authors. Characters expressed in terms of measurement were compared for significance by the use of Student's t-test, the mean values being utilised for this purpose (Table 3): those assigned to different classes A, B, or C (see explanation of Table 2, p. 344) were compared by means of χ^2 (Table 4). The value of P. thus obtained in both cases represents the probability of obtaining by chance as great a deviation as that actually observed. Any probability of less than 0·05 (5%) is considered to be significant.

The subject of the study was described as *Adelpha bredowii* by Geyer in 1837, with an excellent coloured figure, and its habitat given as Mexico. Hewitson in 1848 figured (Doubleday, Westwood, and Hewitson 1846–52 : see Hemming, 1941) a specimen to which Doubleday gave the name "*eulalia*." This was treated as a synonym of *Heterochroa bredowii* by Westwood (*loc. cit.* 1852) but was accepted by Boisduval (1852). Comparison of Geyer's and Hewitson's figures shows marked differences, however, and I revive the name *eulalia* Doubleday for the form figured by Hewitson. Butler (1865) described as a

new species *Limenitis californica* from California, and in 1882 commented that " most Lepidopterists will persist in labelling this species as *H. Bredowii* of Hübner : the latter is a perfectly distinct species." He traces this custom to Edwards (1870). Godman and Salvin (1901) placed *Adelpha bredowii* by itself as a separate, and aberrant, section of the genus, mentioning *A. californica* as a closely allied species : they pointed out that the name *Heterochroa* was preoccupied. Poulton (1908) drew attention to differences between *bredowii* and *californica*, suggesting that these resulted from association (*a*) with the predominant genus *Adelpha* which, in South Mexico, overlaps *bredowii*, (*b*) with *Limenitis lorquini* Bsd. in California. He also suggested, on admittedly slender evidence, that certain peculiarities in specimens from Guatemala result in increased resemblance to the general scheme of coloration of *Adelpha*. He discussed the affinities of *bredowii* and decided to act upon the doubt which Godman and Salvin had expressed, and remove a discordant element from *Adelpha* to *Limenitis* (*s.l.*). I have undertaken a detailed study of the species, based on much more material than was available to Poulton, and upon a survey of all references to it. Detailed measurements to half a millimetre of the size of certain spots, and other characters, have been studied in 218 specimens, and, as a result, the following four races can be defined, one of which is here separated for the first time :—

1. *Limenitis b. bredowii* Geyer 1837 inhabiting only South Mexico.
2. *L. b. eulalia* Doubleday 1848 inhabiting North Mexico (but intruding into South Mexico), Arizona, New Mexico and Texas, with exceptional records from Utah.
3. *L. b. californica* Butler 1865 inhabiting California, the extreme west of Nevada, and Oregon. Rare records from Kansas are attributed to this form but I have not seen a specimen.
4. *L. b. guatemalensis* subsp. n. inhabiting Guatemala with rare exceptions.

The Californian race has a well-marked peculiarity absent from the other three, with extremely rare exceptions which only serve to demonstrate their conspecificity. Other features help to separate it as the most distinct. The other three, each characterised by greater or less development of this or that feature present in the other two, have no important idiosyncrasy.

Male genitalia afford no ground for separating these four, even the two occupying the geographical extremes. But (as Godman and Salvin pointed out (1901)) the genitalia differ considerably from those of other American " *Limenitis*," as shown (fig. 2) in this study, compared with those in Poulton 1909 (plate 5).

II. *Acknowledgements.*

Grateful acknowledgements are made to the Keeper of Entomology, British Museum (Nat. Hist.) for permission to borrow for study specimens in his charge at South Kensington and Tring, and to Messrs. A. G. Gabriel and F. Goodson for kind help at those places. The following most kindly lent or gave specimens : Messrs. H. Blackiston, L. S. Dillon (Reading, Pa.), L. P. Grey (Maine), L. W. Newman, Hy. Turner, and R. C. Williams Jr. of Philadelphia. The author is extremely grateful to the following on both sides of the Atlantic for correspondence : Miss Barbara Prendergast, Messrs. A. Avinoff, H. K. Clench, J. A. Comstock, W. P. Comstock, A. D. Cotton, C. M. Dammers, E. O. Essig, T. B. Fletcher, W. T. M. Forbes, W. Hovanitz, K. Jordan, F. MacFarland, C. H. Morris, V. Nabokov, N. D. Riley, E. C. Van Dyke, R. C. Williams Jr.

Also to the librarians of the following institutions for help in searching out references: Imperial Institute of Entomology; Linnean Society; London School of Hygiene and Tropical Medicine; Royal Society; Royal Botanic Gardens, Kew; Royal Entomological Society of London; Royal Geographical Society; School of Geography, University of Oxford; Science Museum, South Kensington; Zoological Society of London, and the Department of Entomology of the British Museum (Natural History).

III. *Notes on the Genus* Adelpha (Pls. 2 and 3).

One of the objects of this study was to check, with much more material, Poulton's conclusion (1908) that the southern forms of *bredowii* owe some of their features to influence by the pattern of species of *Adelpha*. This genus is closely related to the *Limenitis* complex, showing little difference in venation, but the eyes are much more hairy. A great proportion of the species have, on the upperside, a pattern compounded of orange and white antero-posterior bands crossing the dark brown wings. The whole of the band on the fore-wing may be orange, or only the antero-external part, and the remainder white. A variant of this is a pure white band on the fore-wing in alignment with that on the hind-wing, and a subapical orange patch. An orange anal patch is often conspicuous. The under surface shows the white bands with subsidiary complicated pattern of lighter and darker markings (see Fruhstorfer *in* Seitz 1924, Plates 106–110A, and Plates 2 and 3 (figs. 13–21) of this study).

An interesting feature of some species is a greater degree of acumination of the fore-wing and a straight margin to the hind-wing: this is shown by *A. paroeca* Bates (Pl. 3 fig. 19), *A. felderi jarias* Fruhst. (Pl. 3 fig. 20), and *A. serpa godmani* Fruhst. (Pl. 3 fig. 21).

The genus is abundantly represented in tropical America, ranging north into Guatemala and the southern part of Mexico. I have thought it of interest to collect together the names of species of *Adelpha* with the type of coloration above described, which may be found in areas also inhabited by *L. bredowii*: they overlap in the two countries just mentioned. The list has been compiled from Fruhstorfer (1924) and by examination of specimens at South Kensington and Tring.

Species of *Adelpha*	Mexico	Guatemala
cocala lorzae Bsd.		+
boeotia oberthuri Bsd.		+
erotia delinita Fruhst.		+
phylaca phylaca Bates	+	+
cytherea marcia Fruhst.		+
iphicla iphicleola Bates		+
basiloides Bates	+	+
pithys pithys Bates		+
pithys vodena Fruhst.	+	
donysa Hew.	+	+
naxia epiphicla G. & S.	+	+
ixia leucas Fruhst.	+	+
felderi falcata Godm.		+
felderi jarias Fruhst.	+	
fessonia Hew.	+	
serpa massilia Fldr.	+	
serpa diademata Fruhst.	+	
serpa godmani Fruhst.	+	
serpa celerio Btlr.		+
zea emathia Fldr.	+	
zea paroeca Bates	+	+

Fruhstorfer (1924) remarks that *iphicla* is the chief representative of the great group with isolated and relatively small reddish-yellow pre-apical spot of the fore-wing (*i.e.* the pattern of *L. bredowii*); and that *iphicleola* is common everywhere; *celerio* is one of the commonest species of *Adelpha* in Central America. He says that in Central and South America they form a dominant feature in the fauna. Davis (1928), speaking of British Honduras, says *A. cytheria* is frequently seen in sunny country roads visiting flowers or resting on leaves of bushes by the roadside, whereas *A. iphicla*, in common with other members of its class, frequents shady roads and forest glades. The flight of *Adelpha* is like that of the English "Red Admiral"—very graceful, alternately flapping and then soaring with expanded wings. Moss (1933) records the flight as "elegant but uncertain and difficult to follow. Planing from on high with an occasional flutter *Adelpha* is for a brief moment within reach but is quickly lost to view, seldom, except when drawn by some bait, to be seen returning to the same spot, as do our VANESSIDAE." Mr. W. J. Kaye kindly replied to a question as follows: "I have had plenty of experience with *Adelpha* and taken very many species. Although in my experience few species are really abundant, sometimes in the aggregate several species together make up a considerable number. In Trinidad I have seen *A. iphicla daceleia* Fruh., *A. phylaca trinita* Kaye, and *A. naxia hieronica* Fruh. all flying together on a hillside. The *iphicla* was always the commonest of the three, and if one had luck one might once in a while catch the mimicking Erycinid *Nymphidium maravalica* Seitz, the female of which is a very complete copy of *iphicla* when flying."

It may thus be concluded that, by abundance, conspicuousness, and the simple character of the pattern, at least above, *Adelpha* might well be considered as a possible model for mimetic resemblance, and indeed was accepted as such by Poulton. But none of the comments quoted gives any indication that it has the characters required of a model, *i.e.* fearlessness, slow flight, conspicuous underside when at rest, emission of an acrid odour, and toughness to enable it to withstand experimental handling or tasting by young enemies. Until such evidence is available we are not really justified in concluding that the resemblance of *L. bredowii* in its southern range, now to be discussed, is explicable as true mimicry. Naturalists in Central and South America are asked to note whether vertebrate predators find any degree of relative distastefulness in *Adelpha* when tested by carefully conducted experiments.

Nevertheless, it is a striking fact, as Poulton pointed out (1908 : 476), that the females of some species of *Chloripppe* greatly resemble *Adelpha*, and Fruhstorfer (1924 : p. 546, pl. 110B) comments on this, and on similar resemblance in several species of *Nymphidium* inhabiting Panama, British Guiana, and Trinidad (*loc. cit.* : 711, and Plate 139, h).

IV. *Descriptions of the subspecies of* L. bredowii *Geyer.*

Reference should be made to the tabular statement of the selected characters of each of the 218 specimens, explained in the preliminary to the Tables (p. 344). Also to the Plates.

1. *L. b. bredowii* Geyer 1837. Pl. 1, figs. 5 and 6. Pl. 2, fig. 11. Pl. 4, fig. 22.

Geyer's coloured figure is entirely admirable. It shows the small size, acuminate fore-wings, and straight margin of the hind-wings. The sub-triangular shape of the orange patch, small size of the sub-costal white spots, and large anal orange spots are clearly depicted. I have examined 21 males,

but only a single female could be found. Measurement 1 (a measure of the length of the wing. See Table 1.): Mean of 21 males, 22·6. Range, 24·5 to 20·0. In the single female, 25·5.

♂. *Upper surface. Fore-wing.* The triangular shape of the subapical orange has been noticed only by Geyer (1837) and by Godman and Salvin (1901), but it is important: it is extended backwards by a spot in area 3 which is usually well developed and rarely altogether absent. There may even be also some orange scales in area 2. The sub-costal white spots are smallest in this race, and the extra spot in area 4 is rarely represented; there is a trace of it in Geyer's figure. The white band of the fore-wing (areas 2, 1b, 1a [1]) is in line with that of the hind-wing, and its margins straight except for the universally present notch on the *outer* edge of the spot in 1b. The *inner* margin of this is usually straight, as in fig. 5, or slightly bowed as in Geyer's figure: the notched inner margin in fig. 6 is shown in only three of the twenty-four examined. The white is pure white, compared with the often yellowish-white of *b. californica*. *Hind-wing.* The straight edges of the white band and the non-projecting spot in the base of area 3 are features. Anal orange always well developed, reaching in four specimens across vein 2, which does not occur in other races.

Under surface. Fore-wing. Subapical orange is more markedly extended backwards: there may be a well-developed spot in area 2 and even a few scales in 1b. This orange almost replaces the smoky black ground colour in areas 2 and 3, so conspicuous in *b. californica*. White spot in area 4 little developed. Submarginal and smaller marginal bluish lunules in areas 1a, 1b, 2, and 3, pass anteriorly into a rather faint continuous line which may be lacking as regards the marginal series.

Hind-wing. There is only one basal transverse orange bar, the black borders of which are straight. The specimen illustrated in fig. 11, however, shows a trace of the second which is characteristic of *b. californica*. Bordering the white band, externally, is a blue band which is, compared with that of *b. californica*, narrower posteriorly, but is carried forward continuously of the same width to the costa. Externally to it the discal brown is much redder than the general brown ground colour and especially in areas 2 and 7. The straightened margin of the wing has greatly narrowed this discal brown band. The large submarginal and smaller marginal blue lunules are strongly developed in all areas, and of a more purplish-blue than in *b. californica*. The inner ends of the submarginal lunules are not strongly arched so that the black lines covering each one form in series almost a straight line.

♀. The only female of this race which I have seen is No. 197 in the list, where its characters are given. The normally greater amplitude of the wings in a female nullifies the typical straight margin of the hind-wings and the acuminate fore-wings. The orange patch is less markedly triangular (see Pl. 4 fig. 22).

Poulton (1908 : fig. 9) illustrates a typical *b. bredowii*.

2. *L. b. eulalia* Doubleday 1848. Pl. 1, figs. 3 and 4.

See Doubleday (1848), Boisduval (1852), Edwards (1862, as "*eululia*"), Kirby (1871), Hemming (1941).

This name, proposed by Doubleday, was applied to Hewitson's figure, but in the letterpress Doubleday and Westwood sink *eulalia* as a synonym of *bredowii*. Boisduval used it in 1852. Edwards also used it, misspelt as *eululia*. Kirby set it aside as a synonym and has been followed by all subsequent writers. This

[1] 1a and 1b lie behind and in front of the submedian vein.

is a mistake. Edwards pointed out that *eulalia* had not been described, but only figured by Hewitson. Comparison of this figure with that of Geyer shows clearly the error of synonymy.

A specimen in the British Museum (Natural History) ex Oberthür ex Boisduval bears a M.S. label in minute, old-fashioned writing " donnée par M. Doubleday " and Boisduval (1852) wrote " Cette magnifique *Limenitis*, dont le British Museum avait déjà reçu un individu qui a servir pour la figure qu'en a publiée M. Doubleday, . . .".

The above-mentioned specimen (No. 175 in the table), in appearance, and in measurements of the spots to half a millimetre, so closely corresponds with Hewitson's figure that it may be considered to be the TYPE specimen. Mr. A. G. Gabriel, Assistant Keeper of Entomology, kindly made an independent comparison and wrote : " The specimen from Boisduval's collection agrees exceedingly well with the drawing of *eulalia* on pl. 36, fig. 1, of vol. 2 of Doubleday and Hewitson and may well be the actual specimen from which the drawing was made." I shall therefore allude to this specimen as the TYPE of *eulalia* Doubleday. The locality given is " Mexico " but the list of plates, vol. 1, p. viii, gives " Limenitis Eulalia Venezuela " as a synonym for " Heterochroa Bredowii Mexico." Venezuela is certainly an error.

The following are the characters of *b. eulalia* : they are not given by Edwards' description or figures, which apply to *b. californica.*

It is the largest of the subspecies : but in some respects it is intermediate between *b. bredowii* and *b. californica*, viz., the degree of straightening of the margin of the hind-wing, and the shape of the apex of the fore-wing. The orange patch is roughly quadrangular : the subcostal spots larger than in *b. bredowii* and the spot in area 4 better developed. The female, as usual, has the outline of the hind-wing rounder, and the white markings slightly more developed.

Measurement 1.	Mean of 38 males . . .	26·6	Range 29·0 to 24·0
	Mean of 17 females . .	29·1	Range 31·5 to 28·0
	Doubleday's type . . .	28·5	

♂. *Upper surface. Fore-wing.* The orange patch is wider along the costa than in *b. bredowii* and subquadrangular in shape, or even pentagonal; it is broadest along vein 7. It is rarely extended backwards into area 3 : only in one specimen is there anything more than the few orange scales which can be seen in six only. The subcostal white spots are large and the extra spot in area 4 often shown. The white band is much as in *b. bredowii* : though its margins may be not quite so straight they are straighter than in *b. californica.* It is not quite so well aligned with the band on the hind-wing as in *b. bredowii*, being nearer to the condition of *b. californica* : the white is not noticeably different from that of *b. bredowii.* The inner margin of the spot in 1b is usually straight and never notched. A peculiarity of four specimens from Prescott and Senator in Arizona is that the margin of spot 1b is actually *convex* towards the base of the wing. This minor variation has not been found in any other individual of the species, and is thus of interest as a local feature.

Hind-wing. The white band has much the same character as on the fore-wing. The anal orange is well developed, though not so much as in *b. bredowii.*

Under surface. Fore-wing. The backward extension of the orange patch is more developed than on the upper surface, but does not involve area 2. The extra white spot in 4, when present, is better developed on the under surface.

The submarginal and marginal blue lunules, anterior to those in area 3, lose their lunular character and pass into small spots (submarginal) or into a continuous line becoming broader at the costa (marginal). This blue marginal line is better developed in *b. eulalia* than in any other subspecies.

Hind-wing. The single basal transverse orange bar has straight edges strongly marked with black : in one specimen (No. 146) there is a trace of the second bar which characterises *b. californica.* The blue band, external to the white, is somewhat stronger than in *b. bredowii,* continuous to the costa, and shows slight radiation outwards along some of the veins : this feature is not found in other subspecies. The discal brown area is not so markedly reddish as in *b. bredowii,* though redder than in *b. californica.* The blue submarginal and marginal lunules are very well developed from the anal to the costal angle : the inner margin of each of the large submarginal lunules may be strongly arched, the piers of the arch being continued outwards between the adjoining lunules, or the margin may be almost straight as in *b. bredowii.*

♀. The *female* differs from the male by the more rounded wings.

Poulton (1908 : fig. 4) shows a typical *eulalia* under the name "*bredowi.*" A unique male specimen from the Grand Canyon (the only evidence available that the species occurs there) is No. 122 in the list. The dark ground colour is of a much blacker tint than is usual ; this is especially noticeable on the underside of the hind-wing where the normal light reddish-brown has become almost the same colour as the dark areas in 1b, 2, and 3 of the fore-wing. This does not seem in accord with an interesting conclusion by Skinner (1912) that in the desert country species having any considerable range are paler.

3. *L. b. californica* Butler 1865. Pl. 1, figs. 1 and 2. Pl. 2, fig. 10.

The most widely known and most distinctive race. It differs from *b. bredowii,* as Butler pointed out (1865 and 1882) and Skinner (1911) confirmed, and also from the other two subspecies, by having a second orange bar on the underside of the base of the hind-wing proximal to the white band and across the end of the cell. All of the 120 specimens examined, except three (Nos. 45, 88, and 119), possess this band. Its absence from three specimens, and presence, though poorly developed, in one *b. eulalia* (No. 146) interestingly demonstrate that the difference between these races is one of degree, not of kind. Butler also mentioned that the more rounded wings separate it from *b. bredowii.* Poulton (1908) emphasised the sinuous outline of the white band, of which the hue is distinctly yellowish-white, the small size of the spot in 1a of the fore-wing, and of the anal orange patch.

Another difference, noted by Skinner (1911), is the smaller development of the marginal and submarginal lunules. I have noted a further difference, of the same kind, in the blue band on the outer border of the white on the under surface of the hind-wing (*cp.* fig. 10 with figs. 11 and 12, Pl. 2).

Measurement 1.	Mean of 84 males . . .	23·1	Range 26 to 20·5
	Butler's type . . .	26	
	Mean of 36 females . .	27	Range 30 to 23

Notes on Butler's type, male, No. 95.

It is larger and has the fore-wing slightly more pointed than many other specimens ; in some ways suggesting that it is a mixture of *b. californica* with *b. eulalia.* Unfortunately " California " is the only locality given : and I have

seen no specimen, or record of a specimen, of which the locality shows an overlap into the distribution of *eulalia*.

On the fore-wing the orange patch is markedly pentagonal, and there are a few orange scales in area 3 on the upperside. No trace of the extra white spot in 4. The white band of the hind-wing is rather broader than usual in this subspecies and less sinuous in outline than in many specimens; thus there is a suggestion of *b. eulalia*. The inner margin of the spot in 1b is nearly always strongly notched so that the spot has an hour-glass shape. In Butler's type, however, the margin is straight: another example of the curious fact that a "type" specimen is often not average in appearance! On the under surface of the fore-wing there is (as always) a greater development of orange in area 3, but it forms a spot only in the anterior half of the area: there is no trace of the extra white spot in 4. On the hind-wing the basal orange bar has the black border weakly marked, and it is sinuous, instead of strongly marked and straight as in the other races. The blue band bordering the white externally shows a feature not found in the other races: it ends anteriorly at vein 4, being represented anterior to this only by a dot on each of the veins 5, 6, 7. This is not by any means invariably the case in *b. californica*: but the blue band is always either weak in areas 4 and 5 ("faint anteriorly" in the table) or absent altogether from these areas. The white band itself is less strongly edged with black than in any other race: in fact, the whole underside is less strongly contrasted. The brown discal area of the hind-wing is much paler than in other races, thus contrasting with the very dark blackish-brown of the fore-wing areas 1b, 2, 3, which are the darkest parts of the whole underside, and more extensive than in other races. The marginal blue lunules are present but weakly developed; on the fore-wing they are replaced by faint linear markings. This condition is common, but not universal, in *b. californica*: in a few specimens they are well developed (see table). The submarginal blue lunules are paler than in other races; their inner margins strongly arched, but only faintly marked with black.

The first figure of this subspecies was given by Edwards (1870) and its peculiarities well shown in *both* sexes. The female hardly differs from the male. Other figures are in Mead (1875), and Maynard (1891: in this a spot is shown on the underside of the fore-wing in area 4 but it is incorrectly shaped), Holland (1899), Wright (1906, the somewhat yellowish tint of the white band is emphasised in this), Poulton (1908), Seitz (1924), Comstock (1927, both sexes), Holland (1929).

Variations. The absence of the second orange bar in two specimens has been noted. The marginal blue lunules are not uncommonly quite absent from the hind-wing, but rarely entirely unrepresented on the fore-wing as in No. 98. The anal orange is sometimes all but absent. The white band on the upper surface of the hind-wing is sometimes much shortened posteriorly (as in No. 38). An interesting aberration (No. 96) has the disc of the hind-wing above, between the white band and the submarginal lunules, dusted with orange in areas 2–6. This would certainly have given it a different appearance on the wing.

Specimen No. 54 has the anterior half of the submarginal black lunule on the fore-wing in area 3 orange, but not the common orange dusting which is the backward extension of the orange subapical patch.

4. **Limenitis bredowii guatemalensis** subsp. n. Pl. 1, figs. 7, 8 and 9. Pl. 2, fig. 12.

Poulton (1908: 485) commented upon the extra spot on the fore-wing in area 4 being more developed in two specimens which he had seen from Guatemala. This is clearly shown in his fig. 5, though it is not so large as in some.

It is characteristically developed in all specimens which I have seen from Guatemala, save two collected by Bates and labelled " Guatemala " but probably erroneously, for they are *b. bredowii* only slightly atypical (Nos. 217 and 218 in the list). They both probably came from Mexico, or the border of Guatemala, and are not like Godman and Salvin's specimens from the heart of Guatemala. The spot is always present on the upper surface, and when best developed shows as a triangle the apex of which almost reaches inwards to the level of the inner margin of the spot in area 3.

This subspecies from Guatemala is, in general shape and appearance, intermediate between *b. bredowii* and *b. californica*; in size, nearer the latter.

I have examined nine males and four females only, for it is little known in collections. The HOLOTYPE is No. 203 in the list; the female ALLOTYPE No. 201; both from the Godman–Salvin collection and in the British Museum (Natural History).

Measurement 1.	Mean of 9 males . . .	24·5	Range 26·5 to 23
	Holotype	26	
	Mean of 4 females . .	26·5	Range 27 to 25
	Allotype	27	

♂. *Upper surface. Fore-wing.* The orange patch departs slightly from the polygonal shape of that in *b. californica* and *b. eulalia* towards the triangular shape in *b. bredowii*: it seldom extends into area 3, there being a definite orange spot in that area in only one specimen, a female (No. 201) and a few scales in three males and one female. There is a contrast with *b. bredowii* in the great development of the white spot in area 4. Another feature is that the anterior white band, measured along vein 6 (measurement 4 in the list) is wider in *b. guatemalensis* even than in *b. eulalia*, and far wider than in *b. bredowii*. The inner margin of the white spot in area 1b is usually straight, occasionally slightly bowed, but rarely deeply notched as in *b. californica*. The white band, in general character, is like that of *b. bredowii*. The hind-wing shows maximal development of the anal orange in every specimen.

Under surface. Fore-wing. The spot in area 4, as always, is larger than on the upper surface: in only one specimen (No. 202) is it only of medium size. The submarginal and marginal blue lunules are as in *b. eulalia*, the marginal markings being anteriorly better developed than in *b. bredowii*.

Hind-wing. The second basal orange bar is absent and the margin of the other is straight and strongly marked in black. The blue band is much as in *b. bredowii*, and continuous to the costa. The brown discal area, as in *b. bredowii*, is strongly reddish, contrasting with the paler yellow-brown in *b. californica*: the reddish hue is often strongly developed in area 2 and may affect the outer part of the anal orange.

♀. The *female* shows the usual more rounded outlines.

V. *Distribution* (Text fig. 1) *and habits.*

The following information is compiled from three sources. (i) Data on labels of specimens seen by myself in the collections at Oxford, South Kensington and Tring, or kindly sent me from collections in this country or the United States. Such are indicated by *. (ii) Similar data received through the kindness of correspondents in the States. (iii) Records from Literature. The " Zoological Record " was searched from the first to the last, and all references that seemed likely to bear on the subject were sought out: very few were

unobtainable from one or other of the sources mentioned in the *World List of Scientific Periodicals*.

1. *L. bredowii californica* Butler 1865.

Oregon. Yamhill County (Fender, 1931. The most northern record). Corvallis. Grant's Pass and Sexton. Central Point.* Ashland. Siskiyou.* Sissons.*

California. Mt. Shasta.* Gasquet.* Mendocino.* Trinity County, Carrville. Guerneville. Glenn County. San Francisco neighbourhood (Santa Clara County, Alma,* Fairfax, San Mateo County). Santa Cruz.* Placerville.* Plamas County, Sloat (*teste* R. C. Williams, Jr.). Sonora County, Mark West Springs.* Yosemite.* Fresno County. Huntington Lake. Inyo County, near Mammoth, High Sierras.* King River cañon. Tulare County, Springville. Tehachapi.* Kern County, Havilah. "San Fernando Valley *via* Tejunga cañon* and Little Tejunga cañon."* Los Angeles neighbourhood (Monrovia, Pasadena,* Ridge Route road,* Azusa,* Mt. Lowe*). Orange County, Tobacco Canyon.* San Gabriel mountains.* San Bernardino mountains.* Riverside.* Pala, near San Diego.* "Laguna mountains, San Diego County." Descanso (*teste* R. C. Williams, Jr. This is the only locality known to me in Lower California, politically Mexico).

Nevada. Published records merely state "Nevada." (Maynard, 1891. Holland, 1899. Wright, 1906. Essig, 1926.) But the Director of the Carnegie Museum, Pittsburg, has kindly told me of specimens in his care labelled "Nevada" collected by Meade, probably near Reno, which is close to California and not far from Sloat in Plamas County (*vide supra*). (See specimen No. 56 in Table 1, which also comes from the *eastern* slope of the mountains.)

Utah. Specimens recorded from Utah are so far separated from the normal habitat of *californica* that it has been a surprise to see a specimen from Midway which Mr. R. C. Williams, Junior, kindly sent. It proved to be quite typical. It is noteworthy that the localities in Utah lie in a tongue of greater rainfall (10–20 inches) than in Nevada to the west or Colorado to the east. There are records from Salt Lake City (Browning, 1901), Tooele Canyon (*fide* Wm. P. Comstock), Provo (*teste in lit.* W. T. M. Forbes); Wasatch County, Midway.*

Honduras. This must be mentioned here in order to correct a probable error. Being anxious to know the distribution of the race *guatemalensis* I enquired from correspondents if any record of the species was known from Honduras. Mr. V. Nabokov kindly sent a sketch of a specimen in the Museum of Comparative Zoology, at Harvard College, bearing the data "Honduras. G.G.M." These are not the initials of G. F. Mathew, who collected for Godman and Salvin. It is a very old specimen with both antennae missing. The very clear sketch makes it certain that the specimen is *californica* !

Dr. L. S. Dillon has kindly informed me that in the Public Museum at Reading, Pa., there are two typical *californica* females from "San Pedro (Sula)." It seems certain that there must be an error in labelling. That *californica* should occur in Honduras, separated from its kind by the whole of the area inhabited by *guatemalensis*, *bredowii* and *eulalia* is so unlikely as to require very much more good evidence to establish the fact. The species is not mentioned for Honduras by Godman and Salvin, nor does Davis (1928) record it in his book on the Butterflies of British Honduras.

2. *L. bredowii eulalia* Doubleday 1852.

Colorado. Durango* (*fide* Wm. P. Comstock) in the south-west corner is the only locality for which I can obtain evidence. Mead (1875) gives a definite negative, so it is probable that the species is of rare occurrence here.

FIG. 1.—Distribution of *Limenitis bredowii* Geyer.

Kansas. Scott City (Field, 1940).

Arizona. Grand Canyon.* Prescott* and "Senator"* (Oslar coll.). Sierra Ancha.* Coyote Mountains. Cochise County. Pinaleno Mountains. Fort Grant.* Chiricahua Mountains. Paradise. Santa Rita Mountains

(*teste* A. Avinoff). Huachuca Mountains.* Reef.* Palmer Lee.* Mount Graham (*teste* R. C. Williams Jr.).

New Mexico. Sandoval County, Sandia Mountains and Jemez Springs (*teste* R. C. Williams Jr.). Water Cañon.* Organ Mountains (Cockerell 1899). Fort Wingate.* Guadelupe Mountains, Lincoln Station.*

Texas. Real County, Leaky. Uvalde (Field, 1940). Chisos Mountains (Skinner, 1911). San Antonio. Boorne (*teste* A. Avinoff). Palo Duro Cañon, near Amarillo (*teste* Don. B. Stallings). Specimens recorded as *californica* by Tinkham (1944) from Trans-Pecos are probably *eulalia*.

Mexico. Chihuahua.* Durango City.* Ameccamecca.* Puebla.* Oaxaca.* Pedregal de San Angel.

3. *L. b. bredowii* Geyer 1837.

Mexico. Jalisco (Km. 90 road to Autlan), Michoacan, Carapa (Field, 1939). Uruapan.* Cuernavaca.* Guerrero, Xucumanatlan * 7000 ft. and Omiltene * 8000 ft. Oaxaca.* 12 miles south-west of Oaxaca,* 6100 ft.

4. *L. bredowii guatemalensis* subsp. n.

All records are from the Godman–Salvin collection, except that there are in the Hope Department at Oxford specimens from Guatemala city * by another collector. Central Valleys.* Polochic Valley.* San Geronimo.* Santa Rosa.* Vera Paz.* Dr. Wm. P. Comstock informs me that there is in the American Museum of Natural History a male specimen from Chiapas, Mexico, near Guatemalan border, and that he has seen two more from the same locality.

The distribution of the butterfly (Text fig. 1) probably depends greatly upon that of its food-plant, *Quercus chrysolepis* Liebmann. Commander C. M. Dammers, writing from Riverside, California, says : " It is fairly common here where oak trees grow, and I have taken it on the Mojave Desert just north of here, where it breeds on the dwarf scrub oak of the desert." On this subject Mr. A. D. Cotton, O.B.E., kindly sent the following note from Kew. " *Quercus chrysolepis* occurs from southern Oregon southwards along the mountains to Lower California, reaching its greatest development in the foothills of the Sierra Nevada. It is stated to have a wide distribution in that area and to occur under more varied conditions than any other species of the genus in California. Eastwards it extends to the high mountains of southern Arizona, New Mexico, and the province of Sonora in Mexico. It is not given by Smith in his Enumeration of Guatemala plants and I have no doubt does not occur in that country." Mr. Cotton in a later reply to a query arising from the occurrence of *L. bredowii* in Utah (*vide supra*) added the following information. " Such works as are available now do not include *Q. chrysolepis* in the Utah flora, though *Q. chrysolepis* var. Greene, is given (1890, *Pittonia* **2** : 112) as a synonym of *Q. Wilcoxii* which does occur in Utah. In all the other literature consulted the distribution of *Q. chrysolepis* does not include Utah, but in the *U.S. Dept. Agric. Misc. Publ.* No. 303 (1938) the areas given for *Q. chrysolepis* on the map showing ' Plant Growth Regions of the U.S.' do include a very tiny fragment of the south-east corner of the state."

It is therefore probable that in Guatemala the local race feeds upon some other tree, which may well also occur in Honduras and British Honduras, so that the apparent absence of *L. bredowii* from those countries is interesting. Further knowledge of its distribution in New Mexico, Texas, and Kansas is much desired :

with the exception of Descanso in the extreme north of Lower California, no evidence can be found of the presence of the butterfly in this country. It is known from Colorado by only one record from Durango, for which I am indebted to Dr. Wm. P. Comstock, which makes the more interesting the somewhat melanic specimen (No. 122, taken by the late Mr. W. Dannatt and now in the Oxford Museum) from the Grand Canyon, Arizona. Its unique facies suggests that it is a genuine product of the locality, and it is surprising that no others are known.

A number of *b. eulalia* were collected by Oslar for the late Lord Rothschild from Prescott and Senator, but the known distribution in Arizona is mainly in the south. In Utah the species is little known and in Nevada only from very near to California.

It seems that *b. californica* does not meet *b. eulalia*, and indeed the former is more distinct than any of the others. Dr. Wm. P. Comstock has kindly confirmed my findings. There are specimens of *b. californica*, collected by L. W. Mengel, and bearing a M.S. label " Reef, Arizona ", two of which have been sent me through the kindness of Dr. Lawrence S. Dillon from the Public Museum, Reading, Pa. I think there is certainly an error in the data, and it is significant that other specimens by the same collector, labelled " Honduras ", must certainly be wrongly labelled (see also under *Honduras*, above).

The race *b. eulalia* overlaps *b. bredowii* in South Mexico, and more specimens from Guerrero and Puebla states are greatly desired; definite transitions occur. Although I have little geographical evidence that *b. guatemalensis* overlaps *b. bredowii*, there are two specimens (217, 218) collected by Bates and labelled " Guatemala " which are not typical *b. guatemalensis*; indeed one is nearly *b. bredowii* while the other is transitional in some respects. Possibly they came from the Guatemala–Mexico border.

It does not appear that the races of *bredowii* depend altogether upon considerable rainfall, although it does not inhabit desert areas. I plotted on a large-scale map the curves given in Bartholomew's *Physical Atlas* vol. 3, 1899 (Meteorology), and added the records for the species. The distribution of *b. californica* covers areas of up to sixty inches annual rainfall to less than ten at Tehachapi, though records from areas with so little rainfall are exceptional.

But *b. eulalia* does seem to be associated with drier parts, as most of the records come from localities with rainfall under twenty inches, and a few in areas with less than ten (Water Cañon, and, possibly, Organ Mountains). The specimen from the Grand Canyon is of interest in this connection. Chihuahua, Uvalde, and Scott city lie in a rainfall area of between twenty and thirty, Durango and Oaxaca in Mexico between thirty and forty, and Ameccamecca lies close to the thirty–forty line. The Guerrero specimen might have come from a locality with forty to sixty inches rainfall.

The rainfall in the range of *b. bredowii* is from twenty to sixty inches, and *b. guatemalensis* inhabits rainfall areas of from thirty to about sixty. The statement by Skinner (1912) that in Utah and Arizona species having any considerable range are paler in colour in the desert does not seem to apply to such specimens from these areas as I have seen and studied.[2]

Habitat. Limenitis bredowii californica inhabits shady canyons along mountain sides or by side of creeks, but never in any great numbers: in Yosemite, where it is common, it has been seen coursing up and down roads and

[2] While this was in the press I received a copy of *The biotic provinces of North America* by Lee R. Dice, 1943. The map showing distribution of *bredowii* (Text fig. 1) should be studied in conjunction with this book.

paths like a large dragon-fly. It is evidently a notable butterfly, with distinct personality and is described as a " warrior with a good deal of character " and as " a regal butterfly of dignified demeanour and exclusive habits." It spends much time in solitary flight about the upper branches of the live oaks which it frequents (*Quercus chrysolepis*), and perches on high vantage points, whence it will attack other butterflies and follow down a stone thrown at it. It comes down to offensively-smelling substances and will drink from mud, but does not feed from flowers. One observer found that light clothes repel it but that it would alight on a brown dress. The flight is sailing with wings almost horizontal, alternating with quick beats of the wings. It flies with *L. lorquini* Bsd., which it superficially resembles but from which it can be distinguished by its flight: it is more local than *lorquini*, depending upon the golden-cup oak association. In the Mt. Shasta region it is seldom out of the " transition zone " which " consists chiefly of coniferous forests." These details are gathered from Edwards (1870), Bush (1881), Van Dyke (1892), Wright (1906), Grinnell and Grinnell (1907), Wright (1908), Williams (1909), Comstock (1927), Gunder (1930), Garth (1935).

L. b. eulalia is described by Stone (1921) in Arizona as frequent, especially flying about the trees in small side canyons 6000–6500 ft. during June. Kunze (1898) found it in the canyons of central Arizona with *L. astyanax arizonensis* Edw.

VI. *Some points in the anatomy.*

A. *The male genital armature* (Text fig. 2, A–H).

Godman and Salvin first pointed out (1901, **1**: 296) that in "*Adelpha bredowi* there are three strong teeth near the end of the ventral surface of the harpagones; there is no ascending lobe, and the spine of the tegumen in the middle of the cavity is double." These large ventral teeth are very characteristic of *bredowii*, though, as usual with minor structures, they show considerable variation in size, position, and even in number. One may become doubled on one clasper only as in a specimen of *b. eulalia* (No. 148) in which the central tooth on the right clasper had become two.

One specimen of *b. bredowii* (No. 194) had a fourth, smaller, tooth added anteriorly on the left clasper, which was also found to be the case in No. 190. But in *b. guatemalensis* none of the four specimens examined had more than two of the ventral teeth, and one specimen (No. 199) had only one on the left clasper. This may perhaps be really significant, coupled with the apparent separation of this subspecies, and again suggests the need for knowledge of its existence between the southern limit of its distribution in Mexico as shown in Fig. 1, and Guatemala. At present I have found no evidence that *b. bredowii* and *b. guatemalensis* overlap at all, but there are no certain differences between them, and intermediates occur (Nos. 217 and 218). There is certainly a considerable difference in appearance between the male genitalia of *bredowii* and the other North American species of " *Limenitis*." Eltringham (in Poulton 1914 : Pl. 5) showed that the latter all had a general likeness, and an outline drawing of the structure in *L. weidemeyerii* Edw. is here given for comparison (D). The clasper is much more pointed posteriorly, and has a continuous row of fine teeth, very different from the few large " fangs " of *bredowii*.

But the *weidemeyerii* type is also common to the section of *Adelpha* (Fruhstorfer, in Seitz, 1924 : 510) in which the clasper is without the " dorsal appendage " present in the other section. (Cp. the figures of *A. serpa* (B) and *A. celerio* (C) with that of *L. weidemeyerii* (D).) An example of the other section is

also figured (A) (*A. mesentina* Cr.), and shows the large structure lacking in the first. Fruhstorfer gives no figure of his " dorsal appendage " or " clunicula," and I am at a loss to know what he means by it, for I was unable to find any other appendage than that figured, which seems to correspond with what is usually termed a " harpe," projecting dorsally from the inner surface of the clasper.[3]

This is supported by what Godman and Salvin say (1901) of *Adelpha.* " The

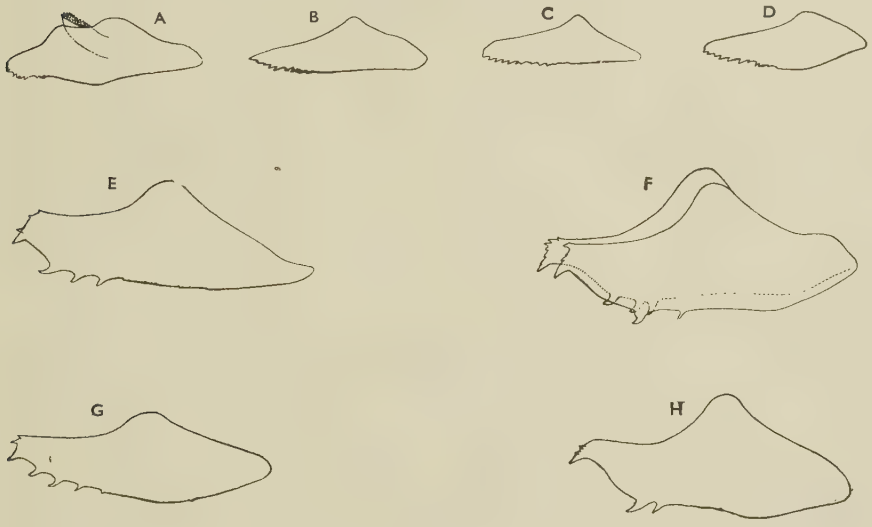

FIG. 2.

External view of the right male clasper, on same scale.

A. *Adelpha mesentina* Cramer.
B. *Adelpha serpa* Boisduval.
C. *Adelpha celerio* Butler.
D. *Limenitis weidemeyerii* Edwards.
E. *Limenitis bredowii californica* Butler. No. 118.
F. *Limenitis bredowii eulalia* Doubleday. No. 148.
G. *Limenitis bredowii bredowii* Geyer. No. 190.
H. *Limenitis bredowii guatemalensis* subsp. n. No. 198.

harpagones in most species have a lobe starting from the middle of the ventral edge and directed upwards and slightly serrated on the inner edge . . . they usually end in a blunt point which is serrate beneath."

B. *Venation.*

There is some variation in the venation of the fore-wing of the American " *Limenitis* " but *bredowii* cannot be definitely separated by it. One variable feature is the point at which the vein giving rise to the 4th and 5th subcostals

[3] As a matter of fact this process really arises from the ventral margin of the clasper which is folded back again so as to lie on the internal surface of the clasper. At one point the margin is greatly prolonged so as to form this distinct process which is shown in lateral view in the drawing. This is clearly shown by Mehta in fig. 104 in his paper on the " Comparative Morphology of the male Genitalia in Lepidoptera " (1933, *Records of the Indian Museum* **35** : 252).

(veins 8 and 7) forks to produce those two. The other is the position of the point of union of the lower discocellular with vein 3 (3rd median). The subjoined table shows, for one specimen of various species, (A) the relative lengths of vein 7 and the main stem proximal to the fork, the first being expressed as a percentage of the latter, (B) whether the origin of the lower discocellular corresponds with the root of vein 3 or is distal to it. It will be seen that the fork in *lorquini*, *bredowii*, *populi* and *archippus* is considerably longer than in other *Limenitis* or *Adelpha serpa*.

	A	B
L. lorquini	80·0	Slightly distal to 3.
L. bredowii californica . .	79·1	Slightly distal to 3.
L. populi	65·3	Distal to 3.
L. archippus	63·2	Distal to 3.
L. astyanax	48·7	At 3.
L. arthemis	43·7	At 3.
L. sibylla	43·4	At 3.
L. weidemeyerii . . .	43·3	Distal to 3.
Adelpha serpa	53·8	At 3.

C. *Life history.*

An account of the life history of *b. californica* was given by Comstock, J. A. (1931). The pupa was illustrated by Comstock, J. A. (1927). See Dyar (1891) and Edwards (1892) for descriptions of larvae of *L. lorquinii* Bsd. and *L. weidemeyeri* Edwds.

The whole question of the larval characters in " *Limenitis* " (*s.l.*) requires much more examination before true relationships can be made out and I have not had time or material for the purpose. I am greatly indebted to Professor W. T. M. Forbes for correspondence on this matter, and venture to quote from a letter dated 15 August, 1943. " It looks now as if there might be three types of larva. A. True *Limenitis*, including *Basilarchia*, with large clubbed spines only on the second thoracic segment (small in *lorquini*, but still larger than the others which are evidently mere rudiments). B. *Moduza*, ' *Adelpha* ' *californica* and *L. camilla*, with two pairs of clubbed spines on the thorax. C. *Pantoporia* and *L. sibylla* (and perhaps *Adelpha*) with branching spines only, but those on the second and third thoracic segments both long."

VII. *Significant differences between the subspecies* (*Tables* 1, 3, 4).

The 218 specimens are tabulated in geographical order from north to south. Nos. 1–120 are of the subspecies *californica*; 121–175, *eulalia*; 176–197, *bredowii*; 198–210, *guatemalensis*. The remaining 211–218 are intermediates. The details in Tables 1 and 2 are of three classes (i) size of spot in millimetres, (ii) size of spot, or larger marking, expressed in degrees A (greatest), B, C (least), or shape expressed as A, B, or C, (iii) other peculiarities. Item No. 3 did not fulfil expectations : it was hoped that it would reveal the degree of apical prolongation of the fore-wing, but the differences were so small that they are not worth printing ; *e.g.* the mean value for *b. bredowii* was 69·9 with extremes of 72·7 and 66·1 ; for *b. californica* the mean was 69·8 with extremes of 75·3 and 65·7. The difference in shape of the fore-wing is so obvious (cf. Plate 1, figs. 1 and 6) that this was unexpected : some other method of arithmetical expression is necessary.

In this section, for brevity's sake, the initial letter only of the subspecific name will be utilised. The characters will be taken in the following order. 1, size. 4, 5, 10, 6, 11, 15, 7, 9, dealing with the white markings. 8, 12, dealing with the orange markings. 13, 14, dealing with the blue markings on the under surface. The full explanation of each character (for which individual measurements are given in Table 1) follows the tables (p. 344).

Before the significant details are discussed it may be mentioned that, as shown in Table 2, there appear to be interesting differences between the specimens from certain localities within the range of one subspecies. For *b. californica*, "Far North" embraces Oregon, Siskiyou, Sissons, Shasta, Gasquet, and Mendocino. "North California" includes all these, together with the neighbourhood of San Francisco, Yosemite, High Sierras, Placerville, Santa Cruz and Mark West. "South California" includes the neighbourhood of Tehachapi, Los Angeles, and a few records from San Diego county and elsewhere. In the case of *b. eulalia* specimens from Central Arizona seemed to show minor differences. Although significance could not be shown, these differences may well prove to be significant when a greater number of specimens from these localities can be examined. Yosemite at least should be able to provide them.

Characters that were not found to show statistical significance were omitted from the following discussion. It should be borne in mind that there was only one female *b. bredowii* for examination.

White markings.

Character 1. Size. Male, *c* differs from *e* ($P < 0{\cdot}001$); *e* differs from *b* and *g* ($P < 0{\cdot}001$); *b* differs from *g* ($P < 0{\cdot}001$). Female, *c* differs from *e* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}01$) and *g* ($P < 0{\cdot}001$). *Sexual dimorphism* is shown in *c* and *e* ($P < 0{\cdot}001$) and in *b* ($P < 0{\cdot}02$). The *coefficient of variability*, never very large, was highest in *c*.

Character 4. Breadth of the subcostal white spots. Male, *c* differs from *b* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}05$); *e* differs from *b* and *g* ($P < 0{\cdot}001$); *b* differs from *g* ($P < 0{\cdot}001$). Female, *c* differs from *e* ($P < 0{\cdot}01$) and from *g* ($P < 0{\cdot}001$); *e* differs from *g* ($P < 0{\cdot}02$). *Sexual dimorphism* in *c* ($P < 0{\cdot}001$). *Coefficient of variability*. *b* stands out as by far the most variable; this could only be investigated in the male.

Character 5. Breadth of spot in area 1A of fore-wing. Male, *c* differs from *e* ($P < 0{\cdot}01$) and from *b* and *g* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}01$) and *g* ($P < 0{\cdot}001$). Female, *c* differs from *e* ($P < 0{\cdot}02$) and from *b* and *g* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}01$) and *g* ($P < 0{\cdot}05$). *Sexual dimorphism* in *b* ($P < 0{\cdot}05$). The difference between the sexes in *b* is greater than that between the extreme races *c* and *g*. *Coefficient of variability* is smallest in *g* and greatest in *c*. The spot in the two southern subspecies in significantly larger than in the two northern subspecies, and in *e* is intermediate between *c* and the southern pair.

Character 10. Breadth of spot in area 7 of hind-wing. Male, *c* differs from *e* and *b* ($P < 0{\cdot}01$); *e* differs from *b* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}02$). Female, *c* differs from *b* ($P < 0{\cdot}01$) and *g* ($P < 0{\cdot}05$); *e* differs from *b* ($P < 0{\cdot}05$). *Sexual dimorphism* in *b* ($P < 0{\cdot}05$). *Coefficient of variability* in both sexes is smallest in *g* and greatest in *e*: all the subspecies except *e* show greater variability in the band on the fore-wing than on the hind-wing.

Characters 5 and 10 indicate the breadth of different parts of the band which crosses both wings: it is interesting to find that in *c* ($P < 0{\cdot}001$), *e* ($P < 0{\cdot}01$), and *b* ($P < 0{\cdot}001$) there is a significant difference in size between adjacent spots on the front- and hind-wings respectively, greatest in *c*.

Character 6. Position of spot, fore-wing 1A. No significant difference between the subspecies was found, but in the females of *c* and *e* the spot is displaced outwards as compared with the males (*c*, $P < 0{\cdot}02$; *e*, $P < 0{\cdot}05$).

Character 11. Position of spot, hind-wing 7. Male, *c* differs from *b* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}02$); *e* differs from *b* ($P < 0{\cdot}02$). Female, *c* differs from *e* ($P < 0{\cdot}05$). *Sexual dimorphism* in *c* ($P < 0{\cdot}02$) and *e* ($P < 0{\cdot}01$), the spot in the female being more distal than in the male. *Coefficient of variability* small in all subspecies but not so small as that for character 6, except in *g*. Just as the pair of characters 5 and 10 show differences between the front- and hind-wings, so do 6 and 11. This point is considered under the next character.

Character 15. A measure of the lack of alignment between the sections of the white band across the two wings. Displacement outwards of the spot on the hind-wing improves the alignment and thus reduces the value of 15. Male, *c* differs from *b* ($P < 0{\cdot}05$); *e* differs from *b* ($P < 0{\cdot}01$). *Coefficient of variability* is high throughout, and is greater in the males than the females of *c* and *g*.

Character 7. Shape of inner margin of spot in fore-wing, 1b. Male, *c* differs from *e*, *b*, and *g* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}001$). Female, *c* differs from *e* ($P < 0{\cdot}001$). *Sexual dimorphism* in *c* ($P < 0{\cdot}001$). Note that *c* stands out as the exception among the males of four subspecies, but the female only shows difference from the other northern subspecies *e*. Thus, by its sexual dimorphism *c* seems to be brought nearer to the two southern subspecies in the female. Only in *c* is the inner margin strongly notched, but even in this subspecies it may be straight. Males show notching more than females (64·3% against 29·7%). No *e* or *g* show notching, nor does the only female of *b*, but 14·3% male *b* do show it.

Character 9. Development of the extra spot in the subcostal series, fore-wing, area 4. *Under surface.* Male, *c* differs from *g* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}02$) and *g* ($P < 0{\cdot}01$); *b* differs from *g* ($P < 0{\cdot}001$). Female, *c* differs from *g* ($P < 0{\cdot}001$); *e* differs from *g* ($P < 0{\cdot}05$). *Upper surface.* *c* differs from *e* ($P < 0{\cdot}02$) and *g* ($P < 0{\cdot}001$); *e* differs from *g* ($P < 0{\cdot}001$); *b* differs from *g* ($P < 0{\cdot}001$). Female, *c* differs from *g* ($P < 0{\cdot}001$); *e* differs from *g* ($P < 0{\cdot}01$). There is a significant difference in the prevalence of the character on the upper and under surfaces, it being better developed below in *c* ($P < 0{\cdot}01$) and *e* ($P < 0{\cdot}05$). Note that *g* stands out from all the others and shows no difference between the upper and under surfaces.

Orange markings.

Character 8. The degree of backward extension into areas 3, or even 2, of the orange subapical patch. Area 3, above. Male, *c* differs from *b* ($P < 0{\cdot}001$); *e* differs from *b* ($P < 0{\cdot}05$). Area 3, below. Male, *c* differs from *e* ($P < 0{\cdot}02$), from *b* ($P < 0{\cdot}001$), and *g* ($P < 0{\cdot}01$); *e* differs from *b* ($P < 0{\cdot}001$); *b* differs from *g* ($P < 0{\cdot}05$). Female, *c* differs from *g* ($P < 0{\cdot}01$). There is a significant difference in the prevalence of the character on the upper and under surface in the males of *c*, *e*, and *b* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}02$), and in the female of *e* ($P < 0{\cdot}01$), the development being greatest below.

Area 2, below. Male, *b* differs from *c*, *e*, *g* ($P < 0{\cdot}001$). Female, *g* differs from *c* ($P < 0{\cdot}01$) and *e* ($P < 0{\cdot}05$). Note that *b* stands out from the others in the greater development of this character which is shown in area 2 on the upperside in this subspecies only.

Character 12. Size of the anal orange spot. Male, *c* differs from *e* and *b* ($P < 0{\cdot}001$) and from *g* ($P < 0{\cdot}02$); *e* differs from *b* and *g* ($P < 0{\cdot}001$).

Female, *c* differs from *e* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}01$). Note that *c* stands out from the others by the small size of the orange spot which is of minimal size (C) in 68·7% of the males and 77·8% of the females. On the whole it is most developed in *g* (100% A) but the maximal individual size is reached in *b*, in which it may cross vein 2 and appear in area 2, as shown in pl. 1, fig. 5.

Blue markings.

Character 13. Condition of blue bar on under surface of hind-wing. Male, *c* differs from *e* and *b* ($P < 0{\cdot}001$) and from *g* ($P < 0{\cdot}01$). Female, *c* differs from *e* ($P < 0{\cdot}001$). Note that *c* male stands out from the others, and in the female from *e*.

Character 14. Condition of marginal lunules on under surface of hind-wing. Male, *c* differs from *e*, *b*, and *g* ($P < 0{\cdot}001$). Female, *c* differs from *e* ($P < 0{\cdot}001$) and *g* ($P < 0{\cdot}05$). Sexual dimorphism in *c* ($P < 0{\cdot}01$). Note that *c* stands out from the others, which agree among themselves, the development being least in *c*.

A character which could not be indicated by measurement is the sinuous external margin of the white band on the hind-wing of *c* and its straightness in the other three (pl. 1, figs. 1 and 2, compared with 3, 6, 9). This is partly due to the projection beyond the general line, in *c*, of a small spot at the base of area 3, which produces an effect analogous to that resulting from the notching of the inner margin of spot 1A (Character 7).

VIII. *Discussion of these differences as regards resemblance to* Adelpha.

The main point in this study being the production of a likeness to species of *Adelpha* in the southern subspecies as opposed to *b. californica* in the north, each will now be considered from that point of view, taking into account the significant differences just described. General statements should be interpreted as referring to mean values.

b. californica.

This, the northernmost subspecies, stands out by the following features: (a) greater variability in the female of characters estimated by measurement; (b) sexual dimorphism in six out of fifteen items considered, as against three in *e* and *b*; (c) smaller size in both sexes of spot fore-wing, 1A (Character 5), than in the other subspecies; (d) greater width of spot hind-wing 7 (Character 10) as compared with fore-wing, 1A; (e) more distal position in the female of spot fore-wing, 1A (Character 6) as compared with the male; (f) more distal position in the female of spot hind-wing, 7 (Character 11) as compared with the male; (*g*) more frequent notching of the inner margin of spot fore-wing, 1A (Character 7) especially in the male; (h) greater development in the male, especially on the under surface, of the extra white spot fore-wing 4 (Character 9); (i) the orange subapical patch of the fore-wing (Character 8) is never maximally developed on the upper surface and is largest on the under surface; (j) the orange anal spot (Character 12) is least developed in this subspecies; (k) the blue band on the under surface of hind-wing (Character 13) is often feebly developed anteriorly (45·0% in male, 47·0% in female) or quite absent anteriorly (8·3% in male, 13·9% in female), neither of which contingencies occurs in the other subspecies; (l) the marginal blue lunules on the under surface of the hind-wing (Character 14) are poorly developed as compared with those of the other subspecies, and may be absent altogether.

b. eulalia.

This shows : (a) sexual dimorphism but less than *c*; (b) greatest size in both sexes; (c) spot fore-wing, 1A (Character 5), of a breadth intermediate between that of *c* and the two more southern subspecies; (d) a narrower spot in hind-wing 7 (Character 10) than in any other subspecies, and greater variability in this character; (e) displacement outwards in the female of spot fore-wing, 1A (Character 6); (f) displacement outwards in the female of spot hind-wing, 7 (Character 11); (g) the coefficient of variability in alignment of the white band (Character 15) smaller than in other subspecies, but as in (*c*) the two halves markedly out of alignment; (h) no notching of spot fore-wing, 1A (Character 7); (i) greater development in the male of the fore-wing orange patch on the under surface (Character 8) but never reaching maximal size; (j) anal orange spot (Character 12) intermediate between that of the subspecies to north and south; (k) a condition of the blue bar and lunules on the under surface (Characters 13 and 14) like that of the southern races (*q.v.*).

b. bredowii.

The fact that only a single female was available resulted in inability to detect significance in many of the characters compared : additional specimens may well bring to light differences in other characters which at present can only be suspected. This subspecies has the following features : (a) sexual dimorphism; (b) the anterior part of the fore-wing band (Character 4) is smaller than in any other subspecies, its mean measurement being smaller than the minimum in any other; (c) the white band is broader on the fore-wing (Character 5) than in the two northern subspecies *c* and *e*, like that of the other southern subspecies *g*. There is sexual dimorphism, the band being markedly wider in the female in which it is wider than in any other subspecies; (d) the white band is broader on the hind-wing (Character 10) than in the two northern subspecies; (e) the spot in hind-wing 7 (Character 11) is displaced outwards in the male, as in *g*, so that there is no difference between the sexes for this character; (f) the alignment of the band (Character 15) is better in the male than in the two northern subspecies *c* and *e*; (g) the notching of spot fore-wing 1A (Character 7) is less than in *c* and more than in *e* : the single female does not show notching; (h) the backward development of the subapical orange patch (Character 8) is greater than in any other subspecies : only in this one is any orange shown in area 2 on the upper surface; (i) the anal orange spot (Character 12) is, as in the other southern subspecies *g*, better developed than in the northern subspecies *e* and *c*; (j) the development of the blue bar (Character 13) is maximal; (k) the development of the blue lunules (Character 14) is maximal.

b. guatemalensis.

This is characterised by : (a) less variability in the measured characters than in any other subspecies; (b) absence of sexual dimorphism in any of the characters investigated; (c) greater width of the anterior end of the white band on the fore-wing (Character 4) than in any other subspecies, the mean value for the male being very nearly twice that for *b*; (d) greater width of spot fore-wing 1A (Character 5), as also in the other southern subspecies *b*, than in the northern subspecies *c* and *e*; (e) spot 7 in hind-wing more nearly approaching fore-wing 1A in width (Character 10) than in any other subspecies; (f) no difference in the sexes between the position of the spots fore-wing 1A and hind-wing 7 (Characters

6 and 11), resulting from the outward displacement in the male; (g) the alignment of the fore-wing band varies less in the female than in the male (Character 15); (h) the extra white spots in area 4 of fore-wing (Character 9) reaches maximal development, and is present in every specimen even on the upper surface; (i) the anal spot (Character 12) as in the other southern subspecies *b* is larger than in the northern subspecies; (j) the blue bar (Character 13) is highly developed; (k) the marginal lunules are highly developed (Character 14).

IX. *Summary.*

The results that have been brought out in the previous section may justly be claimed to confirm statistically Poulton's conclusion (1908) that the features in which southern forms of *bredowii* differ from *b. californica* are those which promote resemblance to *Adelpha* (on the upper surface). But there is a refinement which, owing to the greater number of specimens available, can be added. It appears that the resemblance is to *two types* of *Adelpha* pattern, exemplified in their extreme forms by *A. iphicla iphicleola* Bates (pl. 1 fig. 16) and *A. fessonia* Hew. (pl. 3 fig. 18). The white band on the fore-wing in the former falls short of the costa but in the latter it is continuous broadly to the costa. These opposite conditions are matched by *b. bredowii* (pl. 1 figs. 5, 6) and *b. guatemalensis* (pl. 1 figs. 7, 8, 9).

The following tabular statement sets out in quite general terms (which can be adjusted in detail by the statistical results already given, and Tables 3 and 4) the manner in which a resemblance to *Adelpha* has been developed in the two southern subspecies. The subspecies *eulalia*, geographically intermediate, does not enter into the possibly mimetic relationship.

Character, description	Character No.	*californica*	*bredowii*	*guatemalensis*	*eulalia.*
Colour of fore-wing band	—	Yellowish-white.	White.	White.	White.
External outline of hind-wing band	—	Sinuous.	Straight.	Straight.	Less sinuous.
Subcostal spots, breadth	4	Intermediate.	Least.	Greatest.	Intermediate.
Fore-wing 1A, breadth	5	Least.	Greatest.	Greatest.	Intermediate.
Hind-wing 7, breadth	10	Intermediate (but nearer *e*).	Greatest.	Greatest.	Least.
Hind-wing 7, position	11	Less distal.	More distal.	More distal.	Less distal.
Band alignment	15	Poor.	Best.	Intermediate.	Poor.
Fore-wing 1A, notching	7	Most.	Intermediate.	Least.	Least.
Extra spot fore-wing 4	9 (above)	Least.	Least.	Greatest.	Intermediate. (but nearer *b*).
Orange subapical patch	8	Least.	Greatest.	Intermediate (but nearer *c*).	Intermediate (but nearer *c*).
Orange anal spot	12	Least.	Intermediate (but nearer *g*).	Greatest.	Intermediate (but nearer *c*).
Blue bar	13	Least.	Great.	Great.	Great.
Blue lunules	14	Least.	Great.	Great.	Great.

It is seen that resemblance to *Adelpha* is produced by the white band being of a purer white, straighter in outline in *b. bredowii* and *b. guatemalensis*, and in better alignment on the two wings in *b. bredowii* than in *b. californica*. Also by its greater width in *b. bredowii* and *b. guatemalensis*. The greater conspicuousness of the white band in *b. guatemalensis* is further increased by the filling of a gap in its continuity by means of an additional spot, in area 4 of the front wing.

The condition of the orange markings is parallel. The subapical blotch in *b. bredowii* is extended backwards on the upper surface farther than in any other subspecies, and the orange anal spot is largest in the southern subspecies. The former condition corresponds to the prominence of orange markings external to the white band on the fore-wing in many *Adelpha*, and a large anal orange spot

is often found in that genus. It is often found, in tracing the development of mimicry on the upper surface, that it is due to a character quite frequently shown on the under surface being developed on the upper surface as well. This is the case with the backward extension of the subapical patch more frequently seen in area 3 on the under surface, less often in area 2; but on the upper surface occurring in a smaller proportion of cases in area 3, and very very seldom in area 2. But the specimens in which this last contingency occurs are in *b. bredowii*, which thus resembles *Adelpha*. Similarly, the extra spot in area 4 of the front wing is rarely completely unrepresented below, even in *b. californica*, but is fully developed below in *b. guatemalensis* and is of maximal size above in all females and over three-quarters of the males.

An interesting point is the accentuation of the blue markings on the under surface in *b. eulalia* and the two southern subspecies, which separates them sharply from *b. californica*, presumed to be nearer the ancestral type from which the others have diverged. Inspection of museum specimens does not suggest that this is an approach to the varied pattern of *Adelpha*, although it is possible that seen in life under natural conditions there might be such an approach. Another difference between *b. californica* and the others is the presence of a second orange bar on the underside of the hind-wing; but, again, its absence can hardly be said to contribute to an Adelphoid appearance.

Another general point in the production of a mimetic resemblance is that mimicry is often shown only in the female sex, and that in Lepidoptera the female is more variable. One of the features by which the southern subspecies gain resemblance to *Adelpha* is the suppression of the notching of the inner margin (Character 7) of the spot fore-wing 1B. Now in *b. californica* there is distinct sexual dimorphism in this respect, the notching being less frequent in the female (29·7% against 64·3% in the male), so that it seems that the female has taken the lead in the development of the resemblance to *Adelpha*. Similarly, the reduction in size of the subcostal white spots (Character 4) makes *b. bredowii* more like one type of *Adelpha*: there is sexual dimorphism in this respect also in *b. californica*, the spots being narrower in the female.

The occurrence of quite small variations, of a kind which might well result in the development of a distinct form or local race, is worth comment (see Table 2). Also a small series of seven specimens of *b. californica* from the "High Sierras" shows an apparent characteristic, but greater numbers are required for confirmation. The relative position of the spot in area 1A of the fore-wing seems to be nearer the base of the wing. The mean value for four males is 50·8, the maximum being 53·6; for three females the mean is 51·8, maximum 54·3. These are lower figures than the corresponding ones for any other group of specimens. The corresponding character 11 in the hind-wing does not show this.

Also, in one set of specimens of *b. eulalia* from Arizona there are several showing a peculiarity of Character 7 (*vide* Table 1). The underside of the hind-wing of *b. eulalia* shows a raying-out of the margins of the blue band not found in other races; and the strong arching of the inner edge of the submarginal lunules on the hind-wing of *b. eulalia* and *b. guatemalensis* is another example, the edge being straight in *b. bredowii*.

Minor aberrations have also been noted, *e.g.* the orange colour of the anterior half of a submarginal black lunule in specimens 55, 64, and 78 in *b. californica* and the orange dusting of the disc of the hind-wing in *b. californica* No. 96. Such apparently trivial departures from the normal are yet noticeable in the field, and might well afford natural selection material on which to work. Thus in 1913, *Bedrock* **2**: 361, I recorded a minor variation of the mimetic Nymphaline

Pseudacraea eurytus terra Neave as having looked " distinctly different on the wing " : it had merely a very slight sprinkling of orange scales on part of the black costal margin of the fore-wing.

The question " What are the selective agents ? " requires an answer, and naturalists are again invited to observe in nature. I have, in many papers, endeavoured to show that the attacks of birds are more frequent and of more selective value (*e.g.* 1941, *Proc. zool. Soc. Lond.* (A) **111** : 223–30) than is usually supposed. It is therefore of interest to note beak-marks on two specimens examined during the course of this study. One is the specimen used by Poulton (1908 : fig. 4) as an example of "*bredowi*" from Arizona, which will be found under *eulalia* as No. 139 of the present series. There is a short rather wide beak-mark on the base of the right fore-wing from the costa backwards : the more rubbed apex of the mark even shows in Poulton's figure as a pale spot in the base of area 1b, and there is a rubbed mark on the costa in front of it which was made by the pressure of the left ramus of the beak. The other is a male of *Adelpha plesaure* Hbn. which bears two similar beak-marks on the right fore-wing from the costal margin backwards, one at the base, and one at the middle of the costa. The anterior part of the right hind-wing is mutilated. This specimen may, in the light of the findings in my paper just cited, almost be claimed as evidence that *Adelpha* has some measure of relative distastefulness.

X. *Conclusions.*

1. *Limenitis bredowii* Geyer is separable into four subspecies.

(a) *b. californica* Butler, distributed from Oregon to South California and sparsely occurring in Western Nevada and Utah.

(b) *b. eulalia* Doubleday, distributed in Arizona, New Mexico, Texas, and Mexico. Records from Kansas probably concern this.

(c) *b. bredowii* Geyer, confined to South Mexico, and doubtfully in Guatemala.

(d) *b. guatemalensis* subsp. n. from Guatemala.

2. Evidence is lacking that (a) and (b) meet each other, but (b) and (c) overlap in S. Mexico. Further specimens from this area, and east of California are much needed.

3. The male genitalia show considerable difference from those of other North American *Limenitis* which nearly resemble each other.

4. Fifteen characters were examined in each of 218 specimens of the species and the results are tabulated and discussed.

5. The differences between the subspecies, at present, are of degree rather than of kind, though (a) shows most distinctness in its pattern, and (d) signs of differentiation in its genital armature. There seems evidence of the process of speciation.

6. The conclusion drawn by Poulton in 1908, that the points in which southern individuals of *Limenitis bredowii* differ from northern are those which promote resemblance to *Adelpha* spp., is confirmed and extended.

7. The resemblance is towards two different patterns of *Adelpha*, but cannot logically be claimed as mimicry until evidence is forthcoming that species of *Adelpha* have the characteristics required of models.

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Table 1.

Basic data. For explanation of the characters see p. 344.

No.	Locality	Sex	Fore-wing 1	2	3	4	5	6	7	8 Upper 3	8 Upper 2	8 Under 3	8 Under 2	9 Upper	9 Under	Hind-wing 10	11	12	13	14	Character 15
1	OREGON: Central point	♀	28·0	39·0	71·7	7·6	10·7	51·8	A	—	—	C	—	—	C	14·2	50·0	C	B	B	1·8
2	,, ,, ,,	♂♂	22·0	32·0	68·7	7·8	13·6	50·4	A	—	—	—	—	—	—	11·3	50·4	B	C	B	0·0
3	Siskiyou Co., Winchester	♂♂	23·0	33·5	68·6	10·4	8·6	54·3	B	C	—	A	—	C[1]	B	17·3	47·8	C	B	C	6·5
4	,, ,,	♂♂	24·0	33·0	72·7	6·0	12·5	50·2	C	—	—	A	—	—	C	14·5	44·5	C	A[2]	B	5·7
5	,, ,,	♂♂	22·0	31·0	70·9	8·0	11·3	48·6	B	—	—	C	—	—	C	13·6	43·2	C	A[3]	B	5·4
6[4]	Sissons	♂♂	24·0	34·5	66·3	11·5	12·5	56·2	C	—	—	C	—	—	—	16·6	50·0	B	C	B	6·2
7	,,	♂♂	23·5	34·0	69·1	8·8	12·7	53·1	C	—	—	—	—	C	B	17·0	49·3	B	A[5]	C	3·8
8	,,	♂♂	28·0	38·0	73·6	7·9	10·7	55·3	C	C	—	C	—	—	—	12·5	47·1	C	A[5]	B	8·2
9	,,	♀♀	26·0	37·0	70·2	8·1	11·5	48·0	A	—	—	C	—	C	B	19·0	48·0	B	C	B	0·0
10	CALIFORNIA: Mt. Shasta	♂♂	27·0	38·0	71·0	7·8	7·4	51·8	C	—	—	C	—	—	—	14·8	48·1	C	A	B	3·7
11	,, ,, ,,	♂♂	24·0	34·0	70·5	8·8	8·3	50·0	C	C	—	A	—	—	C[6]	13·0	48·7	C	B	C	1·3
12	,, ,, ,,	♂♂	25·0	35·0	71·1	8·5	14·0	52·4	C	—	—	C	—	C	B	20·0	48·0	C	A[5]	B	4·4
13	,, ,, ,,	♂♂	22·0	32·0	68·7	9·3	13·6	52·2	A	C	—	A	—	—	—	18·1	44·4	C	A	C	7·8
14	Gasquet, nr. Crescent City	♂♂	22·0	31·0	70·9	9·6	11·3	50·9	C	—	—	C	—	—	C	18·1	47·7	B	B	B	3·2
15	,, ,, ,,	♂♂	25·0	34·0	73·5	7·3	12·0	50·0	C	—	—	—	—	—	C	18·0	48·8	B	B	B	1·2
16	,, ,, ,,	♀♀	25·0	33·0	75·7	9·0	12·0	50·0	C	—	—	C	—	—	—	18·0	44·8	C	B	C	5·2
17	Mendocino	♀♀	30·0	40·0	75·0	7·5	6·6	53·3	A	—	—	C	—	—	—	13·3	50·0	C	A[5]	C	3·3
18	Mendocino Co., Coal Creek Cañon	♀♀	26·5	37·0	71·6	8·1	13·2	53·5	C	—	—	—	—	—	C[6]	16·9	45·2	C	B	C	8·3
19	Marine Co., Fairfax	♀♀	28·5	39·0	73·3	7·6	12·2	49·8	B	—	—	C	—	—	C	14·0	47·7	B	B	C	2·1
20	Marine Co., San Rafael	♀♀	23·0	33·0	69·6	7·5	10·8	53·0	B	—	—	C	—	B[7]	A	19·5	55·2	B	A[5]	C	−2·2
21	San Francisco	♂♂	22·0	31·5	69·8	6·3	11·3	53·1	C	—	—	—	—	—	—	11·3	46·3	C	A	C	6·8
22	,, ,,	♂♂	24·5	34·0	72·0	8·5	10·2	51·8	C	—	—	B	—	—	C	16·3	46·9	—[8]	C	B	4·9
23	,, ,,	♂♂	23·5	32·0	73·4	6·2	12·7	55·3	B	—	—	C	—	—	—	14·8	47·6	C	B	B	7·7
24	,, ,,	♂♂	22·5	32·0	70·3	7·8	—[9]	—[9]	C	—	—	—	—	—	C	17·7	51·1	C	C	B	—
25	,, ,,	♂♂	23·5	32·5	72·3	9·2	8·5	55·3	B	—	—	C	—	—	C	17·0	46·8	C	C	B	8·5
26	,, ,,	♂♂	23·5	33·5	70·1	7·4	12·8	49·4	A	—	—	C	—	—	C	17·0	46·8	B	A[5]	B	2·6
27	,, ,,	♂♂	21·5	30·0	71·6	9·3	11·1	45·1	C	—	—	—	—	C	C	18·6	46·5	C	A[5]	B	C	−1·4
28	Santa Clara Co., Alma	♂♂	21·5	31·0	69·3	8·0	11·1	52·0	C	—	—	C	—	—	—	13·9	51·1	C	A[5]	B	C	0·9
29	,, ,, ,,	♂♂	23·5	34·0	68·8	10·2	14·8	56·1	C	—	—	C	—	—	C	23·4	45·5	C	B	C	10·6
30	,, ,, ,,	♀♀	27·0	37·0	72·9	6·7	16·6	50·7	B	—	—	C	—	—	C	5·5[10]	51·8	C	B	C	−1·1
31	Placerville	♀♀	21·5	31·0	69·3	9·6	11·1	52·0	B	—	—	C	—	—	—	20·9	47·4	B	A[5]	C	4·6
32	Santa Cruz	♀♀	28·0	39·0	71·7	6·4	10·7	51·7	A	C	—	A	—	—	—	16·0	47·1	C[11]	B	C	4·6
33	,, ,,	♂♂	24·0	32·0	75·0	9·0	10·6	50·8	C	—	—	C	—	—	C[12]	16·7	45·8	C	B	A	5·0
34	Sonora Co., Mark West Springs	♂♂	23·0	32·0	71·8	9·3	13·0	50·0	B	—	—	C	—	—	C	17·3	47·8	B	B	B	2·2
35	Yosemite	♀♀	26·5	38·0	69·4	7·1	10·1	54·7	C	C	—	C	—	—	—	15·0	49·0	C	C	B	5·7
36	,,	♀♀	27·0	37·0	72·9	9·4	13·3	56·2	B	—	—	C	—	—	C[13]	14·8	48·1	C	C	B	8·1
37	,,	♂♂	24·0	33·5	71·3	7·4	14·5	50·8	C	—	—	C	—	—	C	16·6	50·0	B	B	C	0·8
38[14]	,,	♂♂	22·5	32·0	70·3	7·8	13·3	51·1	A	—	—	C	—	—	—	20·0	49·7	C	B	B	1·4
39	,,	♀♀	26·0	36·5	71·2	9·5	13·4	54·6	A	C	—	C	—	—	—	17·3	50·7	B	C	—[15]	3·9
40	,,	♂♂	22·0	33·0	66·6	9·0	18·6	54·5	A	—	—	C	—	—	C	13·6	47·9	B[16]	B	B	6·6
41	,,	♂♂	21·5	31·0	69·3	8·0	9·3	51·1	A	—	—	—	—	—	C	16·2	47·4	C[17]	A[5]	B	3·7
42	,,	♂♂	23·0	32·0	71·8	9·3	10·7	53·0	C	—	—	—	—	—	C	10·8	48·6	C[17]	A[5]	B	4·4
43	,,	♂♂	23·0	32·0	71·8	7·8	10·8	50·8	C	—	—	C	—	—	C	13·0	45·6	A	A[5]	B	5·2
44	,,	♂♂	23·0	33·0	69·6	7·5	13·0	50·0	C	—	—	C	—	—	C[1]	10·8[2]	46·5	B	A[5]	B	3·5
45[18]	,,	♂♂	23·5	33·0	71·2	9·0	10·6	54·0	B	—	—	C	—	—	C	17·0	51·0	C	A	A	3·0

46	,,	♂♀	23·5	33·5	70·1	7·4	6·7	49·7	B	—	—	C	—	—	C	17·0	46·8	C	A [19]	C	2·9
47	,,	♂♀	25·5	37·0	68·9	8·1	15·6	50·9	C	C	—	C	—	—	—	17·6	49·8	B	C	B	1·1
48	,,	♂♀	25·0	37·0	67·5	8·1	12·0	54·0	A	—	—	—	—	—	—	18·0	48·8	C	A	B	5·2
49	,,	♀	28·5	39·0	73·0	7·6	10·5	54·0	C	—	—	C	—	—	C	14·0	46·8	C	B	A	7·2
50	N. California, High Sierra, 8000–9000 ft.	♂	23·0	34·0	67·6	7·3	10·8	48·6	B	—	—	—	—	—	C	13·0	45·6	C	B	B	3·0
51	,, ,, ,, ,, ,,	♂♂♂	20·5	32·0	64·6	9·0	9·7	53·6	C	—	—	C	—	—	—	17·0	49·7	C [20]	B	B	3·9
52	,, ,, ,, ,, ,,	♂♂♂	24·5	35·0	70·0	8·0	10·2	49·8	B	—	—	C	—	C	B	14·2	47·7	C	B	C	2·1
53	,, ,, ,, ,, ,,	♂♀♀	28·5	38·5	74·6	7·7	12·2	51·2	B	C	—	B	—	—	—	17·5	49·0	C	B	B	2·2
54	,, ,, ,, ,, ,,	♂♀♀	27·0	36·0	75·0	8·0	11·1	50·0	C	—	—	B	—	—	—	14·8	48·1	C	B	C	1·9
55	,, ,, ,, ,, ,,	♀	28·5	41·0	69·5	7·3	14·0	54·3	A [21](L) C(R)	— [22]	—	C	—	—	C [6]	14·0	49·1	C [20]	A [5]	B	5·2
56 [23]	High Sierras, Inyo Co., near Mammoth. Arid E. slope	♂♂	22·5	32·0	70·3	9·3	13·3	51·1	C	B	—	B	—	—	C	17·7	46·6	C	A	C	4·5
57	S. California, Tehachapi	♂♂	23·0	32·5	70·7	12·3	13·0	50·4	C	—	—	C	—	C	C	19·5	48·6	C	B	B	1·8
58	,, ,, ,,	♂♂	23·0	33·0	69·6	8·7	8·6	50·2	B	—	—	C	—	C	B	15·2	48·6	C	A [5]	C	1·6
59	,, ,, ,,	♂♂	24·0	34·5	69·5	8·6	12·5	50·0	B	—	—	C	—	—	C	16·6	46·2	B	A	B	3·8
60	,, ,, ,,	♂	22·5	31·5	71·1	9·5	11·1	52·0	C	—	—	C	—	—	C [29]	15·3	45·3	B	B	C	6·7
61	S. Californian Mts., San Fernando Valley, 4000 ft., via Tejunga Cañon	♂	24·0	34·0	70·5	10·2	12·5	52·0	C	—	—	C	—	—	C	12·5	43·7	C	A [5]	B	8·3
62	Little Tejunga Cañon	♂♂	21·0	31·0	67·0	8·0	14·0	54·7	C	—	—	C	—	—	C	19·0	50·0	C	A	B	4·7
63	Los Angeles	♂♂	23·5	33·0	71·2	9·0	11·1	51·9	C	—	—	C	—	—	—	17·0	46·8	C	B	C	5·1
64	,, ,,	♂♀	25·0	33·5	74·6	8·9	12·0	50·0	B	— [24]	—	C	—	—	—	14·0	46·8	C	A	A	3·2
65	Azusa (nr. Los Angeles)	♂♀	24·5	34·0	72·0	11·7	14·2	51·0	C	—	—	C	—	—	C	16·3	45·7	C	A	B	5·3
66	,, ,, ,,	♂	27·0	39·0	69·2	8·9	12·9	56·2	A	—	—	C	—	—	C	14·8	48·1	C	A	A	8·1
67	Mt. Lowe, nr. Los Angeles	♂♂	20·5	29·5	69·1	10·1	9·7	52·1	C	—	—	C	—	—	C	12·1	47·3	C	B	C	4·8
68	,, ,, ,,	♂♂	21·5	29·5	72·8	10·1	9·3	48·8	C	—	—	C	—	—	—	20·9	45·1	C	B	A	3·7
69	St. Monica Mts., nr. Los Angeles	♂♂	22·0	31·0	70·9	8·0	13·6	52·2	C	—	—	C	—	—	—	20·4	46·3	C	B	A	5·9
70	San Gabriel Mts., nr. Los Angeles	♂♂	25·0	35·0	71·4	10·0	16·0	52·0	C	—	—	C	—	C	B	16·0	44·0	B	A [5]	A	8·0
71	San Bernardino	♂♀	29·0	40·0	72·5	8·7	6·8	55·1	A	C	—	C	—	—	—	17·2	50·0	C [30]	A [5]	B	5·1
72	,, ,, ,,	♂♂	24·0	33·5	71·3	7·4	8·3	54·1	B	—	—	C	—	—	—	16·6	45·8	C	A [5]	B	8·3
73	San Bernardino Co., Oak Glen	♂♂	24·5	34·0	72·0	8·8	12·2	48·8	C	—	—	C	—	—	—	14·2	46·9	C [25]	A	A	1·9
74	,, ,, ,, ,, ,,	♂♂	23·0	32·5	70·7	7·6	8·1	50·0	B	C	—	C	—	—	C	15·2	44·3	C	A	B	5·7
75	Riverside	♂♂	22·5	32·0	70·3	7·8	8·8	53·3	C	C	—	B	—	—	—	15·5	49·7	B	B	B	3·6
76	Glendale	♂♀	24·5	33·5	71·3	7·4	10·2	54·0	A	—	—	—	—	—	—	16·3	46·9	B	A	A	7·1
77	Pasadena	♂♂	23·5	31·5	74·6	11·1	10·6	49·7	C	—	—	C	—	—	C [12]	21·2	44·6	C	B	C	5·1
78	,,	♂♂	23·5	33·5	70·1	8·9	12·0	51·0	C	— [24]	—	B	—	C [1]	B	19·0	45·5	C	A	C	5·5
79	,,	♂♀	23·0	32·0	71·8	9·0	10·8	50·8	C	—	—	—	—	C [6]	C	19·5	44·3	C	B	C	6·5
80	Eaton Cañon, nr. Pasadena	♂	26·0	37·5	69·3	9·3	11·5	55·7	B	—	—	C	—	C [6]	C	19·2	51·9	C	B	B	3·8
81	S. California, Ridge Route Rd.[31]	♂♂	22·0	33·5	65·5	10·4	11·3	53·1	C	—	—	C	—	—	C	13·6	50·0	C	A [5]	B	3·1
82	,, ,, ,, ,,	♂♂	24·5	35·0	70·0	10·0	10·2	49·7	C	—	—	C	—	—	C	14·2	45·7	C	B	C	4·0
83	,, ,, ,, ,,	♂♂	24·5	33·5	73·0	8·9	16·3	53·0	C	—	—	—	—	—	—	14·2	45·7	C	B	C	7·3
84	,, ,, ,, ,,	♂♂	25·5	36·0	70·0	11·1	13·7	51·7	C	C	—	C	—	C	B	19·6	47·0	B	A	C	4·7
85	,, ,, ,, ,,	♂♂	23·5	33·5	70·0	10·4	12·7	51·0	C	—	—	C	—	—	C	19·1	47·8	C	B	B	3·2
86	,, ,, ,, ,,	♂♂	25·0	35·5	70·4	10·0	7·4	48·8	C	—	—	C	—	C	B	12·0	48·0	B	A [5]	C	0·8
87	Orange Co., Tobacco Canyon	♂♂	23·5	32·5	72·3	7·6	12·7	53·1	C	—	—	C	—	—	C [26]	21·2	44·6	C	A	C	8·5
88 [27]	,, ,, ,, ,,	♂♂	24·0	33·5	71·0	8·9	14·1	54·7	C	—	—	C	—	C	B	18·7	50·0	B	A	C	4·7
89 [28]	Pala, nr. San Diego	♂♂	21·0	30·0	70·0	10·0	19·0	52·3	A	—	—	C	—	—	—	19·0	42·8	C	B	B	9·5
90	,, ,, ,,	♂♂	22·0	31·5	69·8	9·5	15·8	53·1	C	—	—	C	—	C	C	18·1	43·1	C [20]	B	B	10·0
91	,, ,, ,,	♂	22·0	32·0	68·7	9·0	15·8	50·9	C	—	—	B	—	—	C	15·9	48·6	C [20]	A [5]	B	2·3

[1] Trace on right only. [2] Continuous, but very faint anteriorly. [3] Continuous, but faint anteriorly. [4] See pl. 1, fig. 1. "Sissons, Oregon, F.D.G." are the data on the label in Brit. Mus. [5] Continuous, but faint anteriorly. [6] Few scales on right only. [7] Larger on right than left. [8] Anal margin broken. [9] Edges of spot not precisely measurable. [10] Exceptionally small spot, an aberration. This specimen was not included in the calculations for Table 2. [11] Very poorly developed. [12] Trace on left side only. [13] Trace on left only. See pl. 1, fig. 2. [14] Band on hind-wing much reduced in area 1C, the spot being very short. [15] Hind-wing border torn, no entry possible. [16] Orange mark faint. [17] Orange mark very faint. [18] Aberrant specimen, lacking the second orange bar on underside at base of hind-wing. [19] Continuous, but faint anteriorly. See pl. 2, fig. 10. [20] Orange spot very small. [21] Outline different on the two sides. [22] Anterior half of submarginal black lunule is orange. [23] One of the few records from the arid eastern slopes; see distribution notes, under Nevada. [24] Anterior half of light lunule near margin is orange. [25] Very faint and small. [26] Minute trace only. [27] The second orange bar is absent from hind-wing underside. [28] Small rather dwarf specimen. [29] Trace on left only. [30] Orange spot very faint. [31] Near Pasadena.

TABLE 1.—*Continued.*

No.	Locality	Sex	Fore-wing											Hind-wing					Character 15
			1	2	3	4	5	6	7	8 Upper 3	8 Upper 2	8 Under 3	8 Under 2	9 Upper	9 Under	10	11	12	13	14	
92	San Diego Co., "Laguna Mts."	♀	27·5	37·5	73·3	9·3	12·7	53·4	C	—	—	C	—	B	A	16·3	46·1	B	A	A	7·3
93	" " " "	♀	27·5	38·5	71·4	10·3	14·4	50·9	B	—	—	B	—	C	C	16·3	48·0	B	A	A	2·9
94	"Central California"	♂	23·0	34·0	67·6	8·8	10·8	50·8	C	—	—	C	—	C	B	19·5	48·6	B	B	C	2·2
95 [1]	California	♂	26·0	38·0	68·0	7·8	5·7	54·6	A	—	—	B	—	C	—	15·3	50·0	A	B	B	4·6
96 [2]	"	♂	23·0	33·0	69·7	7·5	10·8	50·0	A	—	—	—	—	C	B	15·2	44·3	A	A [3]	B	5·7
97	"	♂	23·0	32·5	70·7	10·7	8·7	52·2	B	—	—	B	—	C	B	10·8	48·6	C	B	B	3·6
98 [4]	"	♂	23·0	32·5	70·7	9·2	6·5	48·6	C	—	—	C	—	C	B	15·2	44·3	C	C	C	4·3
99	"	♂	23·5	32·5	72·3	9·2	10·6	54·0	C	—	—	—	—	—	—	17·0	44·6	C	B	B	9·4
100	"	♀	27·0	37·0	72·9	5·1	7·4	55·5	A	—	—	B	—	—	—	12·9	54·4	C	B	B	1·1
101	"	♀	30·0	40·0	75·0	7·5	10·0	51·6	B	—	—	C	—	—	—	15·0	44·6	C	B	B	7·0
102 [5]	"	♀	23·0	32·0	71·8	6·2	13·0	54·3	A	—	—	—	—	—	—	12·6	44·6	C	B	C	9·7
103	"	♀	27·5	38·0	72·5	6·5	12·7	53·4	A	—	—	C	—	—	—	16·3	46·1	C	A [6]	—	7·3
104	"	♀	29·5	40·5	72·8	8·6	13·5	47·4	A	C	—	B	—	C	A	18·6	44·7	C	B	A	2·7
105	"	♀	28·0	40·0	70·0	8·7	14·2	54·2	B	C	—	C	—	—	—	17·8	51·7	C	A [6]	B	2·5
106	"	♀	27·5	37·0	74·3	8·1	12·7	53·4	B	C	—	B	—	—	—	21·8	49·0	C	B	B	4·4
107	"	♂	22·0	32·0	68·7	7·8	9·0	52·2	C	—	—	C	—	C	C	22·7	47·7	B	B	C	4·5
108	"	♂	21·0	30·0	70·0	10·0	14·2	54·7	C	—	—	—	—	C	B	19·0	47·6	C	B	B	7·1
109	"	♂	26·0	35·0	74·2	8·5	9·6	52·6	A	—	—	—	—	B	A	17·3	43·0	C	B	C	9·6
110	"	♀	26·0	39·5	65·8	6·3	11·5	51·9	B	C	—	B	—	—	—	13·4	50·7	C	B	A	1·2
111	"	♂	27·0	38·0	63·1	5·2	11·1	53·7	A	—	—	C	—	—	—	14·7	51·8	C	B	A	1·9
112	"	♂	25·0	35·0	71·4	8·5	12·0	52·0	C	C	—	C	—	C	A	24·0	46·0	B	A	C	6·0
113	"	♂	23·5	34·0	69·1	8·8	10·6	51·9	A	—	—	B	—	—	C	21·2	48·9	C	A [7]	C	3·0
114	"	♂	24·0	35·0	68·7	10·0	10·4	50·0	C	—	—	C	—	C	C	14·5	46·6	B	A [7]	C	3·4
115	"	♂	23·0	32·0	71·8	9·3	13·0	50·0	B	—	—	B	—	B	C	17·3	43·4	B	A [7]	C	6·6
116	"	♂	22·0	32·0	68·7	9·3	11·3	53·1	C	—	—	C	—	—	C	15·4	52·2	C	A [7]	B	0·9
117	"	♂	21·0	29·0	72·4	6·8	19·0	50·9	C	—	—	C	—	—	C	21·4	50·9	C	B	B	0·0
118 [8]	"	♂	23·0	34·0	67·5	8·8	18·6	53·0	B	—	—	B	—	—	C	15·2	46·5	C	B	C	6·5
119 [9]	"	♂	24·0	33·0	72·8	9·0	10·4	48·7	B	—	—	C	—	—	C	14·5	44·5	C	B	C	4·2
120 [10]	UTAH: Wasatch, Midway	♂	22·5	32·0	70·3	6·2	8·8	53·3	C	—	—	C	—	—	C	13·3	48·8	C	C	C	4·5
121	COLORADO: Durango	♀	28·5	41·0	69·5	9·7	14·0	52·6	A	—	—	B	—	—	C	12·2	48·0	C	A	A	4·6
122 [11]	ARIZONA: Grand Canyon	♂	26·0	37·5	69·3	9·3	11·5	48·0	A	—	—	C	—	—	B	11·5	48·0	B	A	A	0·0
123	Prescott, 4000–5000 ft.	♂	27·5	40·0	68·7	8·7	10·9	52·7	A	—	—	B	—	C	B	12·7	46·1	B	A	A	6·1
124 [12]	" " "	♂	27·5	40·0	68·7	8·7	12·7	53·4	A [13]	—	—	C	—	—	B	18·0	45·4	B	A	A	8·0
125 [15]	" " "	♂	26·0	39·0	66·6	10·2	13·4	52·6	A [14]	—	—	B	—	B	A	13·4	43·0	B	A	A	9·6
126	" " "	♀	31·0	44·5	69·6	8·9	11·2	55·4	A [16]	C	—	B	—	—	C	11·2	49·0	B	A	A	6·4
127	Senator, nr. Prescott	♂	25·5	37·0	68·7	9·4	13·7	53·7	A	—	—	C	—	C	C	15·6	47·0	A	A [16]	A	6·7
128	" " "	♂	27·5	40·0	68·7	8·7	16·3	53·4	A [14]	—	—	C	—	C	C	20·0	53·4	B	A	A	0·0
129	" " "	♂	25·5	37·5	68·0	10·6	17·6	53·7	A	—	—	C	—	C	B	15·6	47·0	B	A	A	6·7
130	" " "	♂	26·0	38·5	67·5	10·3	15·3	51·9	A	—	—	C	—	B	A	17·3	46·9	C	A [17]	A	5·0
131	" " "	♂	26·5	38·0	69·7	9·2	16·9	53·5	A	—	—	C	—	—	—	13·2	46·0	C	A	A	7·5
132	" " "	♂	29·0	40·5	71·3	9·8	13·7	51·7	A	—	—	C	—	B	A	15·5	47·2	B	A	A	4·5
133	" " "	♂	29·0	42·0	69·0	9·5	12·0	52·4	A [14]	—	—	C	—	—	C	15·5	48·9	C	A	A	3·5
134	" " "	♀	28·0	40·5	69·1	8·6	12·5	54·2	A	—	—	C	—	B	A	12·5	54·2	A	A [17]	A	0·0
135	" " "	♀	30·0	45·0	66·6	7·7	15·0	55·6	A	—	—	C	—	—	C [18]	15·0	48·3	B	A	A	7·3
136	" " "	♀	28·0	40·0	70·0	10·0	12·5	50·7	A	—	—	C	—	—	C	14·2	50·0	B	A [17]	A	0·7
137	" " "	♀	28·0	41·0	67·1	7·3	14·2	53·5	A	—	—	—	—	—	—	16·0	52·5	B	A	A	1·0

138 [19]	Sierra Ancha	♀	31·5	46·5	67·7	10·7	12·7	53·9	A	B	—	A	C	C	B	14·2	48·2	C	A	A	5·7
139 [20]	Fort Grant	♂	27·5	39·0	70·5	10·2	16·3	51·6	A	C	—	C	—	—	C	12·7	46·1	B	A	A	5·5
140	Huachuca Mts.	♂	27·5	39·0	69·6	8·9	12·7	51·6	A	—	—	C	—	—	—	16·3	49·0	A	A	A	2·6
141	,, ,,	♂	26·0	37·5	69·3	9·3	13·4	49·0	A	—	—	B	—	—	—	13·4	45·0	B	A	A	4·0
142	,, ,,	♂	27·0	38·0	71·0	10·5	11·1	53·7	A	—	—	C	—	B	B	14·8	44·4	B	A	A	9·3
143	,, ,,	♂	27·0	40·0	67·5	10·0	11·1	53·7	A	—	—	C	—	B	A	14·8	50·0	C	A	A	3·7
144	,, ,,	♂	26·0	36·5	71·2	8·1	15·3	50·0	A	—	—	C	—	—	—	13·4	48·7	B	A	A	1·3
145	,, ,,	♂	26·0	38·0	68·4	7·8	13·4	52·6	B	—	—	C	—	—	C	13·4	48·8	C	A	A	3·8
146 [21]	,, ,,	♂	27·0	40·0	67·5	7·5	11·1	53·0	A	C	—	B	—	—	C	16·6	50·7	B	A	B	2·3
147	,, ,,	♂	27·0	39·0	69·2	10·2	12·9	50·7	A	—	—	C	—	—	—	12·9	47·0	B	A	A	3·7
148 [8]	,, ,,	♂	29·0	41·0	70·7	9·7	17·2	53·4	A	B	—	B	—	—	C	18·8	45·5	A	A	A	7·9
149	,, ,,	♂	27·5	40·0	68·7	10·0	10·9	52·0	A	—	—	B	—	—	C	20·0	48·0	B	A [22]	A	4·0
150	,, ,,	♂	28·0	38·5	75·3	9·0	10·7	51·0	A	—	—	B	—	C	B	10·7	48·0	B	A	A	3·0
151	,, ,,	♂	27·0	40·0	67·5	7·5	12·9	52·4	A [23]	—	—	C	—	—	—	14·8	48·1	C	A	A	4·3
152	,, ,,	♂	26·0	37·0	70·2	10·8	11·5	51·9	A	—	—	C	—	C	B	13·4	46·9	C	A	A	5·0
153	Palmer Lee, nr. Huachuca	♂	26·0	36·5	71·2	8·1	13·4	51·9	A	C	—	B	—	—	—	14·2	48·8	B	A	A	3·1
154 [24]	,, ,, ,, ,,	♂	30·0	43·5	68·9	8·0	8·3	54·0	A	—	—	C	—	C	C	11·6	50·6	A	A	A	3·4
155	Cochise Co.	♂	28·5	41·0	69·5	9·7	14·0	52·6	A	—	—	B	—	—	C	12·2	48·0	C	A	A	4·6
156	,, ,, Carr Canyon	♂	26·0	39·0	66·7	8·9	15·3	53·8	A	—	—	C	—	—	C	17·3	50·7	C	A	A	3·1
157	Reef	♂	26·5	39·0	67·9	10·2	15·0	49·0	A	—	—	C	—	B	B	16·9	44·1	B	A	A	4·9
158	,,	♂	26·5	39·0	67·9	10·2	7·5	50·0	A	—	—	B	—	C	B	13·2	45·2	B	A	A	4·8
159	,,	♂	24·5	38·0	64·4	9·2	12·2	51·0	B	—	—	—	—	C	C	18·3	47·7	B	A	A	3·3
160	Chiricahua Mts., Pinery Canyon, 6000 ft.	♂	27·5	40·0	68·7	8·7	12·7	49·8	B	—	—	C	—	—	—	14·5	47·3	C	A	A	2·5
161	Chiricahua Mts., Pinery Canyon, 6500 ft.	♂	27·0	39·0	69·2	8·9	12·9	51·1	A	—	—	B	C	C [25]	B	14·8	50·0	B	A	A	1·1
162	"Arizona"	♂	24·0	35·0	68·5	8·5	12·5	54·1	B	—	—	C	—	—	C	12·5	47·9	B	A	A	6·2
163	,,	♂	30·0	44·5	67·4	8·9	11·6	55·0	A	—	—	C	—	—	C	16·6	51·6	C	A	A	3·4
164	NEW MEXICO: Jemez Springs	♂	25·0	37·0	69·1	9·4	10·0	52·8	A	C	—	B	—	C	C	12·0	44·0	A	A	A	8·8
165	,, ,, ,, ,,	♂	25·0	38·0	65·7	10·5	16·0	56·0	A	C	—	B	—	—	C	14·0	52·8	C	A	A	3·2
166	Fort Wingate	♂	28·0	41·5	67·4	9·6	12·5	54·2	A	C	—	B	—	B	A	16·0	50·0	B	A	A	4·2
167 [26]	Water Canyon	♂	27·0	40·0	67·5	10·0	9·2	50·7	A	—	—	C	—	B	A	12·9	43·3	B	A	A	7·4
168	Guadelupe Mts., Lincoln Station	♂	25·0	36·5	68·4	6·9	12·0	54·0	A	—	—	C	—	—	C	16·0	44·0	C	A	A	10·0
169	TEXAS: San Antonio	♂	26·0	38·0	71·5	7·8	13·4	54·2	A	—	—	C	—	—	C	19·2	51·9	A	A	A	2·3
170	MEXICO: Chihuahua, Pinos Altos	♂	29·0	42·0	69·0	7·1	13·7	51·7	A	C	—	C	—	—	C	13·7	48·2	B	A	A	3·5
171	Durango City	♂	30·0	43·5	68·9	10·3	16·6	55·0	A	—	—	C	—	—	C	20·0	53·3	B	A	A	1·7
172	Ameccamecca	♂	28·0	39·0	71·8	10·2	14·2	51·7	B	—	—	C	—	—	—	21·4	48·2	B	A [7]	A	3·5
173	Puebla	♂	28·0	39·0	71·7	8·9	16·0	52·5	A	—	—	B	C	—	—	17·8	51·7	A	A [7]	A	0·8
174	Oajaca (see also No. 189).	♂	28·0	38·0	71·0	7·1	17·8	51·7	A	—	—	B	—	C [4]	C	17·8	48·2	A	A [7]	A	3·5
175 [27]	"Mexico"	♂	28·5	41·0	69·5	9·7	17·2	53·4	A	—	—	B	—	C	A	20·6	48·2	A	A	A	5·2
176	Mexico, Michoacan, Uruapan	♂	23·0	33·0	69·6	6·0	19·5	55·2	A	A	—	A	A	C	C	19·5	46·5	A	A	A	8·7
177	Guerrero	♂	22·5	32·0	70·3	4·6	16·0	54·4	B	C	—	B	C	—	C	17·7	53·3	A	A	A	1·1
178	,,	♂	22·0	32·0	68·7	4·6	18·1	56·7	C	C	—	A	B	—	—	20·4	48·6	A	A	A	8·1
179	Guerrero, Xucumanatlan, 7000 ft.	♂	24·0	34·5	66·3	2·8	18·7	52·9	A	C	—	A	B	—	—	20·8	47·9	A	A	A	5·0
180	Guerrero, Omiltene, 8000 ft.	♂	23·0	32·5	70·7	4·6	17·3	52·1	B	C	—	A	B [29]	—	C	21·7	50·0	A [28]	A	A	2·1

[1] Butler's TYPE of (subsp.) *californica*. [2] An interesting variety; the disc of hind-wing above between the white band and submarginal lunules is dusted with orange in areas 2–6. Very unusual. [3] Continuous, but faint anteriorly. [4] Marginal blue lunules quite absent from fore-wing as well as hind-wing: unusual. [5] An unusually small female. [6] Continuous, but faint anteriorly. [7] Continuous, but faint in front. [8] Genitalia examined. [9] Genitalia examined. Cf. 44. This also lacks the second orange bar on underside hind-wing. [10] A very typical *californica*. [11] Decidedly melanic: the ground colour a blacker brown than usual. [12] See pl. 1, fig. 3. [13] The margin is convex towards base of wing on the left wing only. [14] The margin is convex towards base of wing. [15] Genitalia examined. [16] Disc of wing, external to the blue, is paler than normal in all areas except 2, where it is the normal dark brown. [17] Outer margin of blue band slightly rayed out along veins. [18] Minute trace on left only. [19] A very large specimen. [20] The specimen has been seized by a bird which left a clear beak-mark upon the base of the right fore-wing. [21] This specimen has a trace of the second orange bar on the underside of hind-wing, upon the discocellular. [22] Outer margin of blue band rayed out along veins. [23] Slightly convex towards base of wing. [24] See pl. 1, fig. 4. [25] Trace on right only. [26] Under surface of hind-wing in areas 2 and 7 is more pronouncedly red than usual. [27] Doubleday's TYPE of (subsp.) *eulalia*. [28] Also an orange spot in area 2. [29] Also some orange scales in area 1b.

TABLE 1.—*Continued.*

No.	Locality	Sex	Fore-wing 1	2	3	4	5	6	7	8 Upper 3	8 Upper 2	8 Under 3	8 Under 2	9 Upper	9 Under	Hind-wing 10	11	12	13	14	Character 15
181	Guerrero, Omiltene, 8000 ft.	♂	23·0	32·5	70·7	4·6	15·2	57·3	A	C	—	B	C	—	C	15·2	53·0	A	A	A	4·3
182	" " "	♂	22·0	31·0	70·9	2·4	18·1	54·5	B	C	—	A	B	—	—	18·1	50·0	A [1]	A	A	4·5
183	" " "	♂	23·5	33·0	71·2	4·5	16·4	51·9	A	C	—	A	B	C	C	19·0	49·5	A [2]	A	A	2·4
184 [3]	" " "	♂	22·0	32·5	67·6	3·0	15·9	53·6	A	—	—	A	B	—	—	18·1	50·0	A	A	A	3·6
185	" " 1700–2000 m.	♂	23·0	32·5	70·7	6·1	19·5	53·0	B	C	—	A	B [4]	C	B	21·7	52·1	A	A [5]	A	0·9
186	" " " "	♂	22·5	31·0	72·5	6·4	13·3	53·3	C	C	—	B	C	—	—	22·2	46·6	A	A	A	3·3
187	S. Mexico, Oaxaca	♂	24·5	35·0	70·0	8·5	12·2	51·0	A	C	—	B	C	—	C	20·0	47·7	A	A	A	3·3
188 [6]	" "	♂	24·0	33·0	72·7	4·5	12·5	50·0	C	C	—	A	A	—	C	16·6	45·8	A	A	A	4·2
189	Oajaca (see also No. 174).	♂	24·0	34·5	66·3	8·6	14·5	48·7	B	C	—	B	—	—	—	16·6	47·9	B	A	A	0·8
190 [9]	12 miles S.W. of Oaxaca, 6100 ft.	♂	20·5	31·0	66·1	6·4	14·6	48·7	B	A	C	A	B	—	[7] C	17·0	49·7	A [7]	A [5]	A	−1·0
191	" " " "	♂	20·0	30·0	66·6	6·6	15·0	52·5	B	C	—	A	B	—	C	17·5	53·5	A	A [5]	A	−1·0
192	" " " "	♂	21·5	31·5	68·2	4·7	11·1	52·0	B	A	—	A	B	—	—	16·2	49·7	A	A	A	2·3
193	" " " "	♂	22·0	32·0	68·6	7·8	11·3	53·1	A	C	—	A	B	—	C [8]	20·4	50·9	A	A [5]	A	2·2
194 [9]	Cuernavaca	♂	23·0	32·0	71·8	3·1	15·2	53·0	A	A	—	A	B	C	C	15·2	42·1	A	A	A	0·9
195	"Mexico"	♂	22·5	32·0	70·3	6·2	11·1	52·0	A	C	—	A	B	C	C	17·7	48·8	A	A	A	3·2
196	"	♂	22·5	32·5	69·2	6·1	13·3	51·1	A	A	C	A	A	C	C	20·0	52·0	A	A [5]	A	−0·9
197 [10]	"	♀	25·5	36·5	—	8·2	21·6	51·9	A	—	—	B	C	—	—	23·5	50·9	A	A	A	1·0
198 [11]	Guatemala, Santa Rosa, Vera Paz	♂	25·0	35·0	71·4	11·4	16·0	52·0	A	—	—	B	—	B	A	18·0	48·8	A	A	A	3·2
199 [9]	Guatemala, Polochic Valley	♂	23·0	33·0	69·6	12·1	19·5	50·8	A	C	—	B	—	A	A	15·4	48·6	A	A [5]	A	2·2
200 [12]	" " "	♂	25·0	34·5	72·4	13·0	14·0	52·8	A	—	—	C	—	A	A	20·0	50·8	A	A [5]	A	2·0
201 [13]	" " "	♀	27·0	37·5	72·0	10·6	16·7	52·5	A	B	—	B	C	A	A	20·3	50·0	A	A	A	2·5
202	" " "	♂	23·0	33·0	69·6	10·6	15·2	53·0	A	—	—	B	—	C	B	19·5	48·6	A	A	A	4·4
203 [14]	Guatemala, San Geronimo	♂	26·0	36·0	72·2	11·1	15·3	53·8	B	—	—	C	—	A	A	15·4	50·0	A	A	A	3·8
204	" " "	♀	27·0	38·0	71·0	13·1	18·5	57·4	A	C	—	B	C	A	A	16·6	54·4	A	A	A	3·0
205	Guatemala, Central Valleys	♂	27·0	36·5	73·4	9·5	18·5	53·7	A	—	—	B	—	A	A	18·5	48·8	A	A	A	4·9
206	Guatemala City, 4000–5000 ft.	♂	24·0	34·0	70·5	8·8	20·8	54·1	A	C	—	B	C	A	A	16·6	47·9	A	A [5]	A	6·2
207	" " " "	♂	26·5	36·0	73·6	11·1	15·0	53·5	A	—	—	B	—	A	A	15·0	49·5	A	A	A	4·0
208 [9]	Polochic Valley	♂	24·0	35·0	68·5	11·4	16·6	54·1	A	C	—	B	C	A	A	16·6	50·0	A	A	A	4·1
209	"Guatemala"	♀	25·0	34·5	72·4	9·8	14·0	48·4	A	—	—	B	—	A	A	— [15]	— [15]	— [15]	A	A	—
210 [9]	"	♂	24·0	34·0	67·6	13·2	16·6	52·0	A	—	—	C	C	A	A	16·6	47·9	A	A	A	4·1
211 [16]	Texas, Chisos Mts.	♂	23·5	34·5	68·1	11·5	8·5	51·0	A	—	—	C	—	—	—	14·8	49·7	B	A	A	—
212 [17]	Mexico, Guerrero	♂	24·0	36·0	66·6	8·0	12·5	54·1	A	—	—	C	—	—	C	18·7	42·5	A	A	A	—
213 [18]	" "	♂	24·5	34·5	71·0	8·6	20·4	51·0	B	—	—	C	—	C	C	20·0	45·7	A	A	A	—
214 [19]	Mexico, Oajaca	♂	24·0	34·5	69·5	8·6	14·5	48·7	B	C	—	B	—	[8] —	—	16·6	47·9	B	A	A	—
215 [19]	"Mexico"	♂	26·0	36·5	71·2	8·9	19·2	50·0	B	—	—	C	—	—	C	19·2	50·0	A	A	A	—
216 [20]	Mexico City	♂	25·5	37·0	68·8	6·7	11·7	52·9	A	—	—	—	—	—	C	12·7	48·9	A	A	A	—
217 [21]	"Guatemala"	♂	22·0	32·0	68·7	4·6	18·1	54·5	B	—	—	A	B	—	C	15·1	48·6	A	A	A	—
218 [21]	"	♂	23·5	34·0	69·1	7·3	17·0	48·9	B	—	—	C	—	—	C	19·0	47·6	A	A	A	—

[1] Also an orange spot in area 2. See pl. 1, fig. 5. [2] Very large and continued over area 2. The first lunule is replaced by orange except for a small trace of its base. [3] See pl. 2, fig. 11. Shows a trace of a second orange bar on underside of hind-wing. [4] Also a few orange scales in area 1b. [5] Continuous, but faint anteriorly. [6] See pl. 1, fig. 6. [7] Also an orange spot in area 2. [8] Few scales on right only. [9] Genitalia examined. [10] Collected by the late W. Dannatt, and purchased from the executors for the Oxford Museum. [11] Genitalia examined. See pl. 1, fig. 8. [12] See pl. 2, fig. 12. [13] See pl. 1, fig. 9. ALLOTYPE. [14] Genitalia examined. See pl. 1, fig. 7. HOLOTYPE. [15] Hind-wings broken. [16] By small size, rather pointed fore-wing and slightly triangular fore-wing orange patch, and absence of second orange bar on hind-wing below, this seems transitional from *eulalia* to *bredowii*. [17] Transitional from *eulalia* to *bredowii*. Smaller than normal *eulalia*. Fore-wing subapical orange not so triangular as in true *bredowii*. [18] Transitional from *eulalia* to *bredowii* in shape of fore-wing subapical orange. Fore-wing costal white spots of *eulalia* form. Fore-wing not pointed, and hind-wing rounded. [19] Transitional from *eulalia* to *bredowii* in shape of fore-wing subapical orange. [20] Transitional from *eulalia* to *bredowii* in shape of wings, but not of fore-wing orange. Costal spots small. Anal orange large. [21] Collected by Bates, and in Godman–Salvin collection. Although labelled "Guatemala" they lack the usual characteristic spot in 4, having only a trace underneath. The subapical orange patch on fore-wing is transitional between the condition in *bredowii* and that in *guatemalensis*.

Table 2.

Possible local variations. For explanation of the characters see p. 344.

Subspecies and locality.	Sex.	Char.	1	4	5	10	6	11	Char.	7	8 Above 3	8 Above 2	8 Below 3	8 Below 2	9 Above	9 Below	12	13	14
eulalia Central Arizona	♂ 9	Mx.	27·5	10·6	17·6	20·0	53·7	53·4	A	100·0	0	0	0	0	0	22·2	11·1	100·0	100·0
		Mn.	*26·4*	*9·5*	*14·3*	*15·3*	*52·5*	*47·0*	B	0	0	0	22·2	0	22·2	33·3	66·6	0	0
		Mi.	25·5	8·7	10·9	11·5	51·9	43·0	C	0	0	0	77·8	0	33·3	33·3	22·2	0	0
	♀ 7	Mx.	31·0	10·0	15·0	16·0	55·6	54·2	A	100·0	0	0	0	0	0	28·6	14·3	100·0	100·0
		Mn.	*29·0*	*8·8*	*13·0*	*14·3*	*53·4*	*50·0*	B	0	0	0	14·3	0	28·6	0	71·4	0	0
		Mi.	28·0	7·3	11·2	11·2	50·7	47·2	C	0	14·3	0	71·4	0	0	57·1	14·3	0	0
californica Far North California	♂ 11	Mx.	25·0	11·5	14·0	20·0	56·2	50·4	A	18·2	0	0	36·4	0	0	0	0	45·5	0
		Mn.	*23·3*	*8·7*	*11·9*	*16·1*	*51·7*	*47·5*	B	18·2	0	0	0	0	0	27·3	45·5	36·4	63·6
		Mi.	22·0	6·0	8·3	11·3	50·0	43·2	C	63·6	27·3	0	36·4	0	27·3	45·5	54·5	18·2	36·4
	♀ 7	Mx.	30·0	9·0	13·2	19·0	55·3	50·0	A	—	0	0	0	0	0	0	0	42·9	0
		Mn.	*27·2*	*8·0*	*10·3*	*15·5*	*52·0*	*47·6*	B	—	0	0	0	0	0	14·3	14·3	42·9	71·4
		Mi.	25·0	7·5	6·6	12·5	48·0	45·2	C	—	14·3	0	85·7	0	14·3	28·6	85·7	14·3	28·6
californica Yosemite	♂ 9	Mx.	24·0	9·3	18·6	20·0	54·5	51·0	A	—	0	0	0	0	0	0	11·1	16·7	0
		Mn.	*22·9*	*8·1*	*12·0*	*15·0*	*51·7*	*48·2*	B	—	0	0	0	0	0	0	33·3	16·7	66·7
		Mi.	21·5	7·4	6·7	10·8	50·0	46·5	C	—	0	0	77·8	0	0	88·9	55·6	66·7	22·2
	♀ 6	Mx.	28·5	9·5	15·6	18·0	56·2	50·7	A	—	0	0	0	0	0	0	0	48·6	20·0
		Mn.	*26·4*	*8·3*	*12·5*	*16·1*	*54·1*	*48·9*	B	—	0	0	0	0	0	0	33·3	37·8	80·0
		Mi.	25·0	7·1	10·1	14·0	50·9	46·8	C	—	50·0	0	83·3	0	0	33·3	66·7	13·5	0
californica All North California.	♂ 37	Mx.	25·0	11·5	18·6	23·4	56·2	55·2	A	16·2	0	0	10·8	0	0	2·7	2·8	48·6	5·4
		Mn.	*23·0*	*8·4*	*11·7*	*16·2*	*51·7*	*47·9*	B	29·7	0	0	5·4	0	2·7	10·8	33·3	37·8	56·8
		Mi.	20·5	6·0	6·7	10·8	45·1	43·2	C	54·1	8·1	0	59·5	0	13·5	62·2	63·9	13·5	35·1
	♀ 19	Mx.	30·0	9·5	16·6	19·0	56·2	51·8	A	35·0	0	0	5·3	0	0	0	0	26·3	5·3
		Mn.	*27·2*	*7·9*	*11·8*	*15·7*	*52·4*	*48·4*	B	20·0	0	0	10·5	0	0	5·3	21·0	47·4	73·7
		Mi.	25·0	6·7	6·6	13·3	48·0	45·2	C	45·0	31·6	0	73·7	0	5·2	36·8	79·0	26·3	15·8
californica South California.	♂ 29	Mn.	25·5	12·3	19·0	20·9	54·7	50·0	A	3·4	0	0	0	0	0	0	0	51·7	10·3
		Mn.	*23·1*	*9·4*	*12·0*	*17·0*	*51·5*	*46·5*	B	13·8	0	0	10·3	0	0	17·2	20·7	48·3	44·8
		Mi.	20·5	7·4	7·4	12·0	48·8	42·8	C	82·8	10·3	0	82·8	0	27·6	55·2	79·3	0	44·8
	♀ 8	Mx.	29·0	10·0	16·0	19·2	56·2	51·9	A	—	0	0	0	0	0	12·5	0	87·5	75·0
		Mn.	*26·4*	*9·1*	*12·1*	*16·3*	*53·4*	*47·7*	B	—	0	0	12·5	0	12·5	12·5	50·0	12·5	25·0
		Mi.	24·5	7·4	6·8	14·0	50·9	44·0	C	—	12·5	0	75·0	0	25·0	37·5	50·0	0	0

In the right-hand half of the table the figures represent percentages for each class. Since Characters 8 and 9 are sometimes not shown the sum of the percentages given does not always equal 100.

Table 3.

Measured characters.

The subspecies *californica*, *eulalia*, *bredowii* and *guatemalensis* are indicated by their initial letters.

	♂				♀			
	c	e	b	g	c	e	b	g
Character 1								
Number	84	38	21	9	36	17	1	4
Maximum	26·0	29·0	24·5	26·5	30·0	31·5	—	27·0
Mean	23·10	26·55	22·62	24·50	27·04	29·09	25·5	26·50
Minimum	20·5	24·0	20·0	23·0	23·0	28·0	—	25·0
Standard deviation	±1·42	±1·10	±1·12	±1·22	±1·58	±1·14	—	±1·00
Standard error of mean	±0·15	±0·18	±0·24	±0·41	±0·26	±0·28	—	±0·50
Coefficient of variability	6·13	4·14	4·93	4·99	5·83	3·90	—	3·77
Character 4								
Number	84	38	21	9	36	17	1	4
Maximum	12·3	10·8	8·6	13·2	10·0	10·7	—	13·1
Mean	8·81	9·24	5·34	11·41	7·90	8·96	8·2	10·75
Minimum	6·2	6·9	2·4	8·8	5·1	7·1	—	9·5
Standard deviation	±1·15	±0·99	±1·75	±1·32	±1·22	±1·12	—	±1·63
Standard error of mean	±0·13	±0·16	±0·38	±0·44	±0·20	±0·27	—	±0·82
Coefficient of variability	13·03	10·67	32·74	11·53	15·46	12·46	—	15·20
Character 5								
Number	83	38	21	9	36	17	1	4
Maximum	19	17·6	19·5	20·8	16·6	17·8	—	18·5
Mean	11·67	13·09	15·18	16·56	11·84	13·72	21·6	16·93
Minimum	5·7	7·5	11·1	14·0	6·6	8·3	—	14·0
Standard deviation	±2·73	±2·28	±2·70	±2·22	±2·35	±2·39	—	±2·13
Standard error of mean	±0·30	±0·37	±0·59	±0·74	±0·39	±0·58	—	±1·06
Coefficient of variability	23·37	17·41	17·81	13·40	19·86	17·44	—	12·56
Character 10								
Number	84	38	21	9	35	17	1	3
Maximum	24·0	20·0	22·2	20·0	21·8	21·4	—	20·3
Mean	16·66	14·93	18·65	17·01	15·85	15·64	23·5	18·47
Minimum	10·8	10·7	15·2	15·0	12·6	11·2	—	16·6
Standard deviation	±3·00	±2·42	±2·13	±1·80	±2·14	±3·09	—	±1·85
Standard error of mean	±0·33	±0·39	±0·47	±0·60	±0·36	±0·77	—	±1·07
Coefficient of variability	18·03	19·01	15·31	10·56	13·48	19·78	—	10·02
Character 6								
Number	83	38	21	9	36	17	1	4
Maximum	56·2	56·0	57·3	54·1	56·2	55·6	—	57·4
Mean	51·65	52·17	52·71	52·90	52·74	53·24	51·9	53·00
Minimum	45·1	49·0	48·7	50·8	47·4	50·7	—	48·4
Standard deviation	±2·03	±1·73	±2·21	±1·12	±2·24	±1·50	—	±3·71
Standard error of mean	±0·22	±0·28	±0·48	±0·37	±0·37	±0·36	—	±1·85
Coefficient of variability	3·92	3·32	4·19	2·12	4·24	2·82	—	6·99
Character 11								
Number	84	38	21	9	36	17	1	3
Maximum	55·2	53·4	53·5	50·8	54·4	54·2	—	54·4
Mean	47·20	47·49	49·31	49·12	48·29	49·78	50·9	51·07
Minimum	42·8	43·0	42·1	47·9	44·0	47·2	—	50·0
Standard deviation	±2·25	±2·55	±2·77	±0·99	±2·46	±2·14	—	±2·95
Standard error of mean	±0·25	±0·41	±0·60	±0·33	±0·41	±0·52	—	±1·70
Coefficient of variability	4·77	5·37	5·61	2·02	5·08	4 28	—	5·77
Character 15								
Number	83	38	21	9	36	17	1	3
Maximum	10·6	10·0	8·7	6·2	9·7	7·3	—	4·9
Mean	4·50	4·72	2·76	3·78	4·44	3·45	1	3·47
Minimum	−2·2	0·0	−1·0	2·0	−1·1	0·0	—	2·5
Standard deviation	±3·61	±2·57	±2·59	±1·25	±2·75	±2·09	—	±1·27
Standard error of mean	±0·40	±0·42	±0·56	±0·42	±0·46	±0·51	—	±0·73
Coefficient of variability	80·27	54·54	93·79	91·71	61·90	60·47	—	36·51

Contingencies.

The subspecies *californica*, *eulalia*, *bredowii* and *guatemalensis* are indicated by their initial letters.

Degree of development of character.	♂								♀							
	c		e		b		g		c		e		b		g	
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Character 7																
A	11	13·1	34	89·5	10	47·6	8	88·9	15	40·5	16	94·1	1	—	4	100·0
B	19	22·6	4	10·5	8	38·1	1	11·1	11	29·7	1	5·9	0	0	0	0
C	54	64·3	0	0	3	14·3	0	0	11	29·7	0	0	0	0	0	0
Character 8 in area 3, above																
A	0	0	0	0	5	23·8	0	0	0	0	0	0	0	0	0	0
B	1	1·2	1	2·6	0	0	0	0	0	0	1	5·9	0	0	1	25·0
C	7	8·3	6	15·8	15	71·4	3	33·3	11	30·6	2	11·8	0	0	1	25·0
D	76	90·5	31	81·6	1	4·8	6	66·7	25	69·4	14	82·3	1	—	2	50·0
Character 8 in area 3, below																
A	4	4·8	0	0	16	76·2	0	0	1	2·8	1	5·9	0	0	0	0
B	10	11·9	14	36·8	5	23·8	6	66·7	7	19·4	5	29·4	1	—	4	100·0
C	55	65·5	23	60·5	0	0	3	33·3	24	66·7	10	58·8	0	0	0	0
D	15	17·9	1	2·6	0	0	0	0	4	11·1	1	5·9	0	0	0	0
Character 8 in area 2, below																
A	0	0	0	0	3	14·3	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	13	61·9	0	0	0	0	0	0	0	0	0	0
C	0	0	1	2·6	4	19·0	3	33·3	0	0	2	11·8	1	—	2	50·0
D	84	100·0	37	97·4	1	4·8	6	66·7	36	100·0	15	88·2	0	0	2	50·0
Character 9 above																
A	0	0	0	0	0	0	7	77·8	0	0	0	0	0	0	4	100·0
B	3	3·6	7	18·4	0	0	1	11·1	1	2·8	2	11·8	0	0	0	0
C	20	23·8	9	23·7	6	28·6	1	11·1	4	11·1	4	23·5	0	0	0	0
D	61	72·6	22	57·9	15	71·4	0	0	31	86·1	11	64·7	1	—	0	0
Character 9 below																
A	3	3·6	5	13·2	0	0	8	88·9	2	5·6	3	17·6	0	0	4	100·0
B	15	17·9	9	23·7	1	4·8	1	11·1	2	5·6	1	5·9	0	0	0	0
C	46	54·8	16	42·1	13	61·9	0	0	10	27·8	10	58·8	0	0	0	0
D	20	23·8	8	21·0	7	33·3	0	0	22	61·1	3	17·6	1	—	0	0
Character 13																
A	3	3·6	5	13·2	20	95·2	9	100·0	0	0	5	29·4	1	—	4	100·0
B	23	27·7	22	57·9	1	4·8	0	0	8	22·2	8	47·1	0	0	0	0
C	57	68·7	11	28·9	0	0	0	0	28	77·8	4	23·5	0	0	0	0
Character 13																
A	39	46·4	38	100·0	21	100·0	9	100·0	14	38·9	17	100·0	1	—	4	100·0
B	38	45·2	0	0	0	0	0	0	17	47·2	0	0	0	0	0	0
C	7	8·3	0	0	0	0	0	0	5	13·9	0	0	0	0	0	0
Character 14																
A	5	6·0	37	97·4	21	100·0	9	100·0	11	31·4	17	100·0	1	—	4	100·0
B	41	49·4	1	2·6	0	0	0	0	20	57·1	0	0	0	0	0	0
C	37	44·6	0	0	0	0	0	0	4	11·4	0	0	0	0	0	0

Note.—For Characters 8 and 9 there is a fourth class, D. This is because these characters are not always present, and D represents the number and percentage of absences.

Explanation of Tables 1, 2.

Fore-wing characters.

1. Length of vein 1 (submedian) from base to end. A measure of the expanse of wing.

2. Length from base of median vein to end of vein 7 (subcostal 5).

3. Measurement 1 expressed as percentage of measurement 2.

4. Breadth of the subcostal white spots, where vein 6 (upper radial) separates them, expressed as percentage of measurement 2.

5. Breadth of spot in area 1A expressed as percentage of measurement 1.

6. Relative position of spot 1A indicated by the distance of its mid antero-posterior line from the base of the wing, expressed as percentage of measurement 1. The mid line was obtained by taking the mean of measurements from base of wing to outer and inner margins of the spot.

7. Shape of inner margin of spot in area 1B; whether (A) straight (pl. 1, fig. 9), (B) bowed, with concavity towards base of wing (fig. 5), (C) strongly notched (fig. 1).

8. Amount of orange in areas 3 and 2, on upper and under sides. (A) large spot; (B) small spot; (C) only a minute spot, or a few scales; (D) none at all.

9. Extra white spot in the subcostal series, in area 4, on upper and under sides. (A) Full size reaching approximately to the inner end of the spot in area 3; (B) medium to small; (C) minute, or only a few scales; (D) not shown.

Hind-wing characters.

10. Breadth of spot in area 7 expressed as percentage of measurement 1.

11. Relative position of spot 7 expressed in same way as Character 6.

12. Anal orange spot: size in relation to the outer of the two black lunular markings. The orange covers the innermost as a cap but may not extend outwards as far as the apex of the outer lunule (least developed, condition C); it may reach the apex (B) or extend beyond it when most developed (A). As an excessive development it may cross over vein 2. Plate 1, fig. 2 shows C; fig. 4, B, and fig. 5, A.

13. Condition of blue bar on under surface, bordering the white. (A) continuous to costa though often fainter anterior to vein 4, as in pl. 2, figs. 11, 12; (B) very weak or broken but at least partly present anterior to vein 4; (C) absent anterior to vein 4 (pl. 2, fig. 10).

14. Condition of blue lunules on margin of under surface of the wings. (A) strongly developed (pl. 2, fig. 12); (B) weakly developed; (C) almost or quite absent (pl. 2, fig. 10). They are usually more strongly marked on the hind-wing and when feebly developed on the front wing become a series of linear markings.

15. This was added after the pairs of Characters 5 and 10 and 6 and 11 had been worked out, as it was found that the mid line of the spot in area 7 of the hind-wing varied in position and it was desired to know whether this was due to displacement of the spot. Character 15 represents the difference between 6 and 11.

ENGRAVED BY STAR ILLUSTRATION, LONDON.

The Subspecies of **Limenitis bredowii Geyer 1837.** *Uppersides.* *About two-thirds natural size.*

ENGRAVED BY STAR ILLUSTRATION, LONDON.

The Subspecies of **Limenitis bredowii Geyer 1837** *and species of* **Adelpha.** *Undersides. Slightly reduced.*

Species of **Adelphia.** *Uppersides.* *Natural size.*

ENGRAVED BY STAR ILLUSTRATION, LONDON

The unique female of
Limenitis b. bredowii Geyer.

Natural Size

Explanation of Plates.

Plate 1.

Subspecies of *Limenitis bredowii* Geyer 1837.

Fig. 1. *L. b. californica* Butler 1865 ♂. No. 6 in list. Sissons, Oregon.
2. *L. b. californica* Butler 1865 ♀. No. 36 in list. Yosemite.
3. *L. b. eulalia* Doubleday 1848 ♂. No. 124 in list. Prescott, Arizona.
4. *L. b. eulalia* Doubleday 1848 ♀. No. 154 in list. Palmer Lee, South-east Arizona.
5. *L. b. bredowii* Geyer 1837 ♂. No. 182 in list. Omiltene, Guerrero, Mexico, 8000 ft.
6. *L. b. bredowii* Geyer 1837 ♂. No. 188 in list. Oaxaca, Mexico.
7. *L. b. guatemalensis* subsp. n. ♂. Holotype. No. 203 in list. San Geronimo, Guatemala.
8. *L. b. guatemalensis* subsp. n. ♂. No. 198 in list. Santa Rosa, Vera Paz, Guatemala.
9. *L. b. guatemalensis* subsp. n. ♀. Allotype. No. 201 in list. Polochic Valley, Guatemala.

All the specimens are in the British Museum (N.H.).

Plate 2.

Subspecies of *Limenitis bredowii* Geyer 1837 and species of *Adelpha*. Undersides.

Fig. 10. *L. b. californica* ♂. No. 46 in list. Yosemite.
11. *L. b. bredowii* ♂. No. 184 in list. Omiltene, Guerrero, Mexico, 8000 ft.
12. *L. b. guatemalensis* ♂. No. 200 in list. Polochic Valley, Guatemala.
13. *Adelpha iphicla iphicleola* Bates (= *massilides* Fruh.) ♀. Polochic Valley, Guatemala.
14. *Adelpha serpa godmani* Fruhstorfer ♂. Cordova, Mexico.
15. *Adelpha fessonia* Hewitson ♂. Jalapa, Mexico.

All the specimens are in the British Museum (N.H.).

Plate 3.

Species of *Adelpha*. Uppersides.

Fig. 16. *A. iphicla iphicleola* Bates (= *massilides* Fruhstorfer) ♂. Guerrero, Mexico.
17. *A. basiloides* Bates ♀. Cordova, Mexico.
18. *A. fessonia* Hewitson ♂. Mexico.
19. *A. paroeca* Bates ♀. Cordova, Mexico.
20. *A. felderi jarias* Fruhstorfer ♀. Cuesta de Misantla, Mexico.
21. *A. serpa godmani* Fruhstorfer ♀. Cordova, Mexico.

All the specimens are in the British Museum (N.H.).

Plate 4.

Fig. 22. The unique female of *L. b. bredowii* from the collection of the late W. Dannatt. "Mexico." In the Oxford University Museum. (Natural size.)

Explanation of Charts 1 and 2.

Charts 1 and 2 (for which G.D.H.C. is alone responsible) show, for the 210 specimens of the four subspecies of *L. bredowii*, the distribution of each subspecies (indicated by its initial letter) in respect of Character 5 (breadth of spot in fore-wing area 1A) and Character 4 (breadth of subcostal spot), both expressed as percentages of the length of a vein. The curve in each case is bisected in the middle to save space, the right half (references to abscissae on the right) being placed under the left half (references on the left). The distribution of each character shows a definite cline, but it is noteworthy that for Character 5 the race *b. bredowii* is on the right side, showing high development of the spot whereas for Character 4 it is on the left side, being poorly developed. The subspecies *b. guatemalensis* occupies the right (maximal) end of each curve, *b. eulalia* the central part, while *b. californica* is distributed very nearly throughout each curve; *i.e.* it shows the greatest extent of variation.

Two specimens cannot be included in chart 1: the unique female of *b. bredowii* because its value, 21·6%, puts it above the top of the chart, and No. 24 (*b. californica*) because the wing being torn no measurement of the spot was possible. Female specimens are indicated by a dot under the letter.

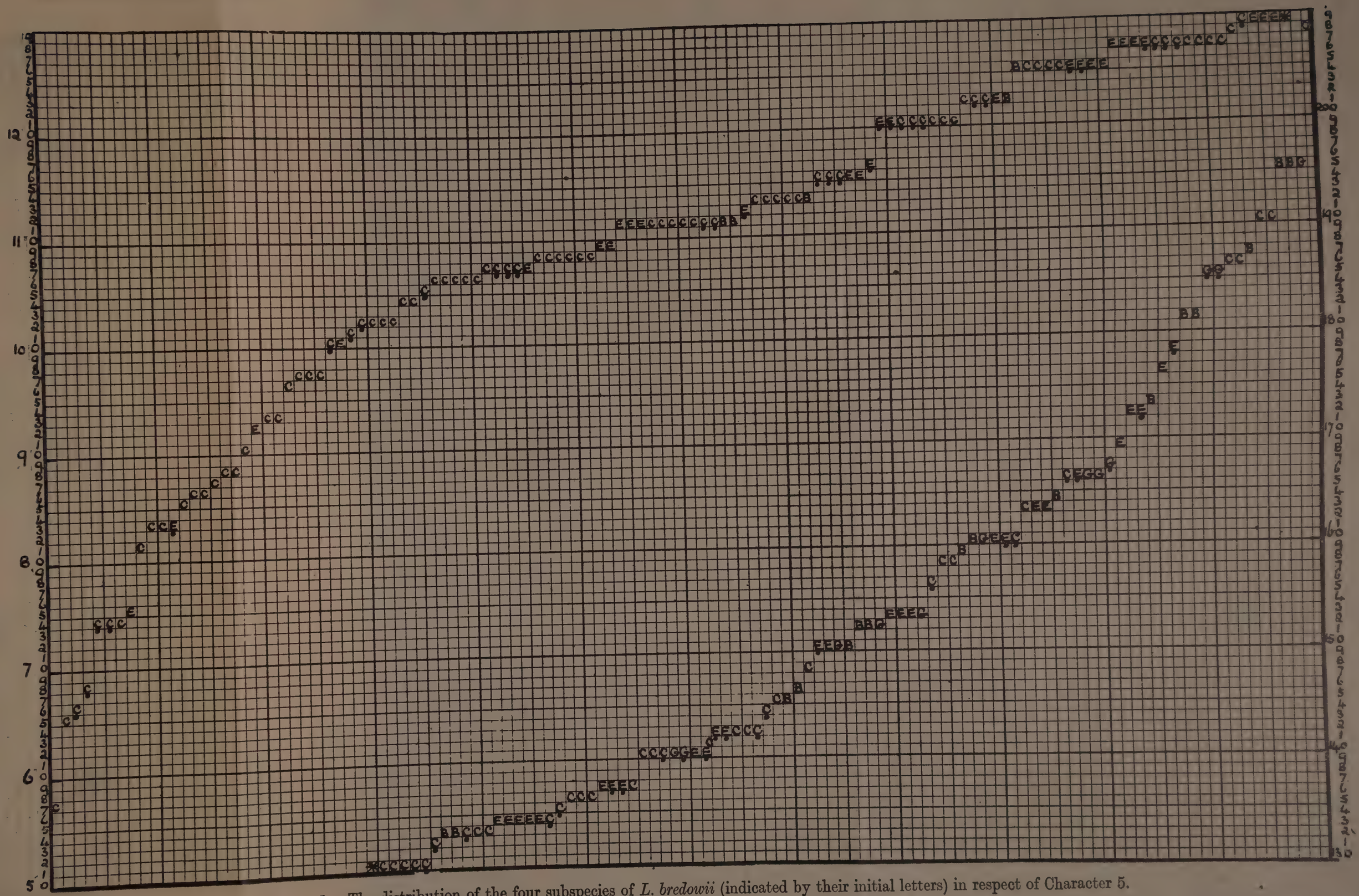

CHART 1.—The distribution of the four subspecies of *L. bredowii* (indicated by their initial letters) in respect of Character 5.

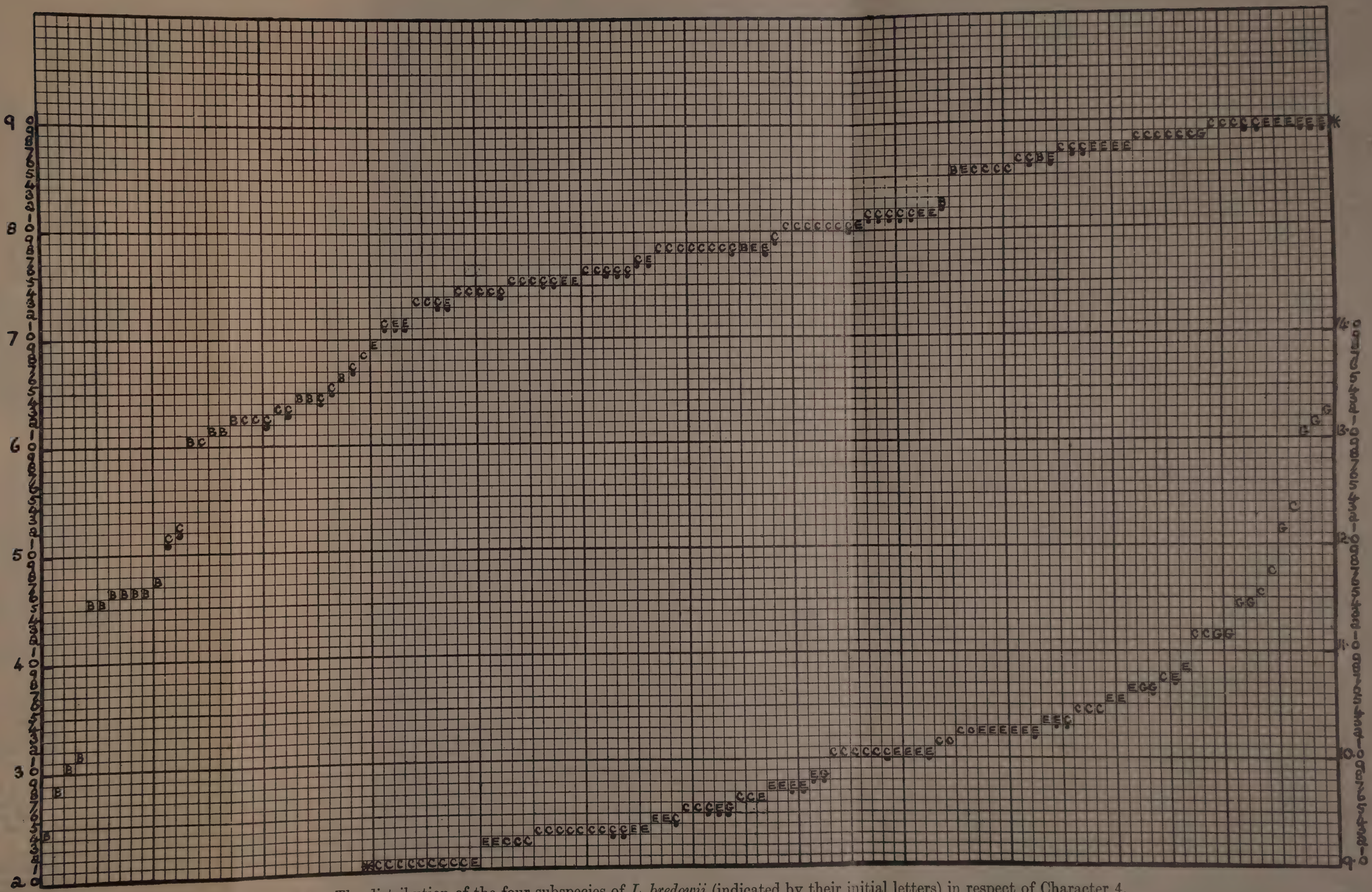

CHART 2.—The distribution of the four subspecies of *L. bredowii* (indicated by their initial letters) in respect of Character 4.

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